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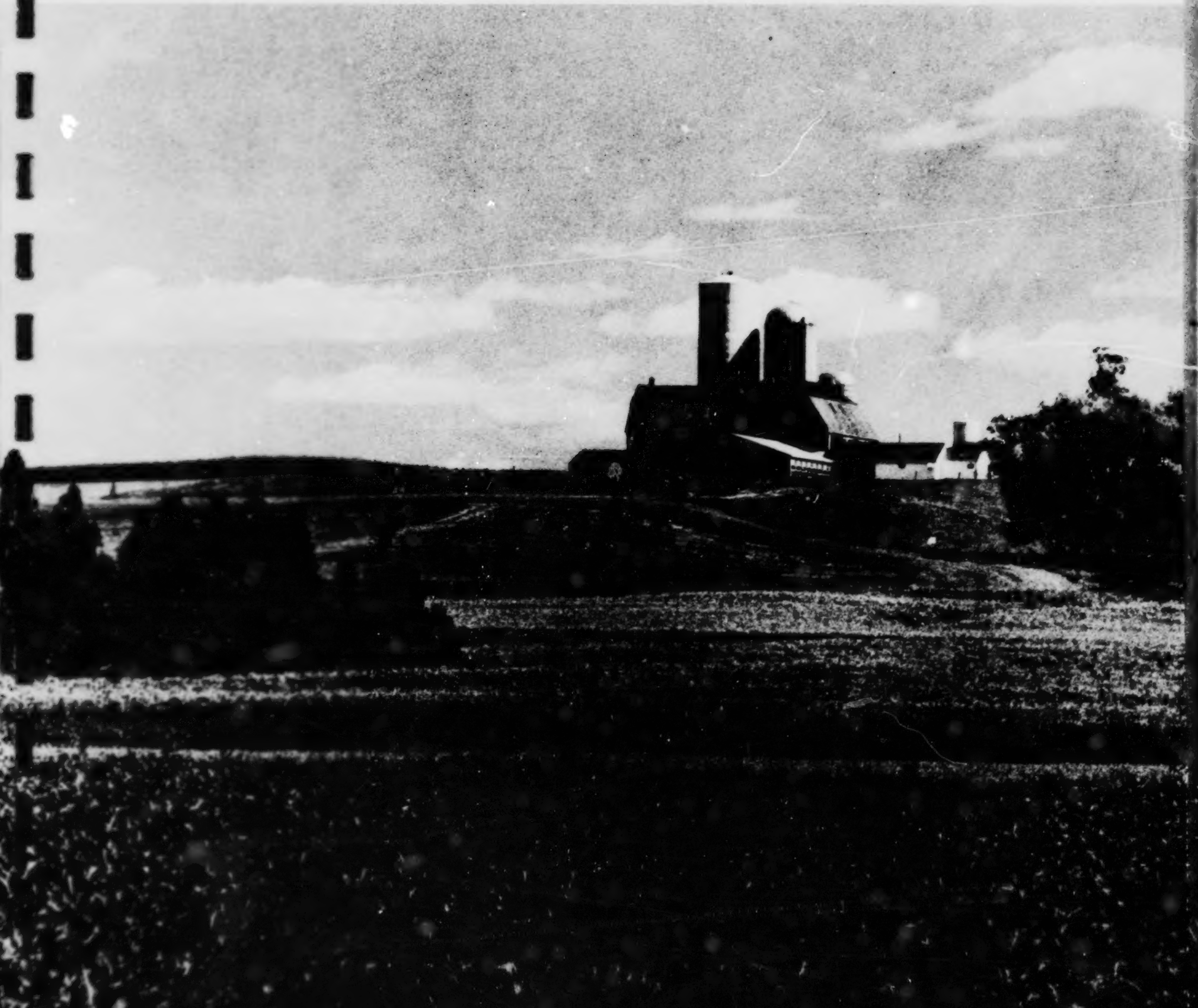
Energy and Agriculture

Ontario

Ontario Energy and Agriculture
Policy Committee

Volume 2
Summary of Research Findings



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Volume 2
Summary of Research Findings

Ontario

Ministry of Energy

Ministry of Agriculture and Food

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PREFACE

In June 1980 the Ontario government established the Energy and Agriculture Policy Committee to examine the future supply, demand, and price of energy and their implications for the production of food in Ontario. The Committee was to recommend policies and programs that would help agriculture meet these challenges and take advantage of the opportunities presented by the changing energy environment, to recommend a long-range strategy for energy management in Ontario agriculture, and to develop an outline for a five-year agricultural energy management program. The Report and Recommendations of the Committee were presented in a summary volume in September 1981. This companion volume presents the supporting research used to formulate the conclusions and recommendations presented in Volume 1.

This volume has been prepared by the Ministries of Agriculture and Food and Energy with the concurrence of the Committee. However, it does not necessarily reflect the views of the Committee. In some cases the Committee's interpretation of the research results differed from those of the consultants. For example, the levels of energy conservation potentially attainable presented by the research consultants were judged by the Committee to be too high; the projections outlined in the Committee's Report were thus somewhat lower.

The contents of this volume are essentially the research results as presented to the Committee by the research consultants. Its structure differs from that of the first volume in following more closely the treatment of topics in the research reports. This volume is based in turn on those reports, which are listed in Appendix A and available to the public in the libraries of the Ministries of Agriculture and Food and Energy. In making publicly available the research findings on which the Committee's Report was based, the Committee and the Ministries involved are seeking to contribute to a wider understanding of the facts and issues in the increasingly important area of energy and agriculture. They wish to thank the twenty-six organizations that submitted briefs to the Committee. Many of those briefs are summarized in Appendix R.

CHAPTER 1

AGRICULTURE IN ONTARIO

This chapter describes the present state of agriculture in Ontario, its resource base, production, markets, export competition, and energy requirements. The chapter then examines the province's resources in land, new products, and technology to consider the potential for agricultural development over the next twenty years.

RESOURCE BASE FOR AGRICULTURAL PRODUCTION

Soils

The outstanding feature of Canadian physiography is the dominance of the Canadian Shield (Figure 1.1). The Shield covers 47 per cent of the area of Canada and 61 per cent of the area of Ontario. While much of it is not suited to agriculture, it contains significant pockets of soils that are being farmed, or could be. For instance the two clay belts, the Great Clay Belt in the Cochrane - Kapuskasing area and the Little Clay Belt in the New Liskeard area, are significant agriculturally at present and could be further developed. Other smaller agricultural areas within the Shield in Ontario occur near Dryden, Emo, Thunder Bay, Verner, North Bay, and Sudbury, and there are even smaller pockets of 40-80 hectare farms.

Of most interest to agriculture in Ontario, however, are the St Lawrence Lowlands on the southern border of the Shield (Figure 1.2). This area of 156 000 square kilometres, or 1.5 per cent of Canada's land surface, is the base for agriculture in central Canada. It is also the location of the densely populated and industrialized Quebec City - Windsor Corridor.

The gradual process of soil formation can be arbitrarily divided into two stages:

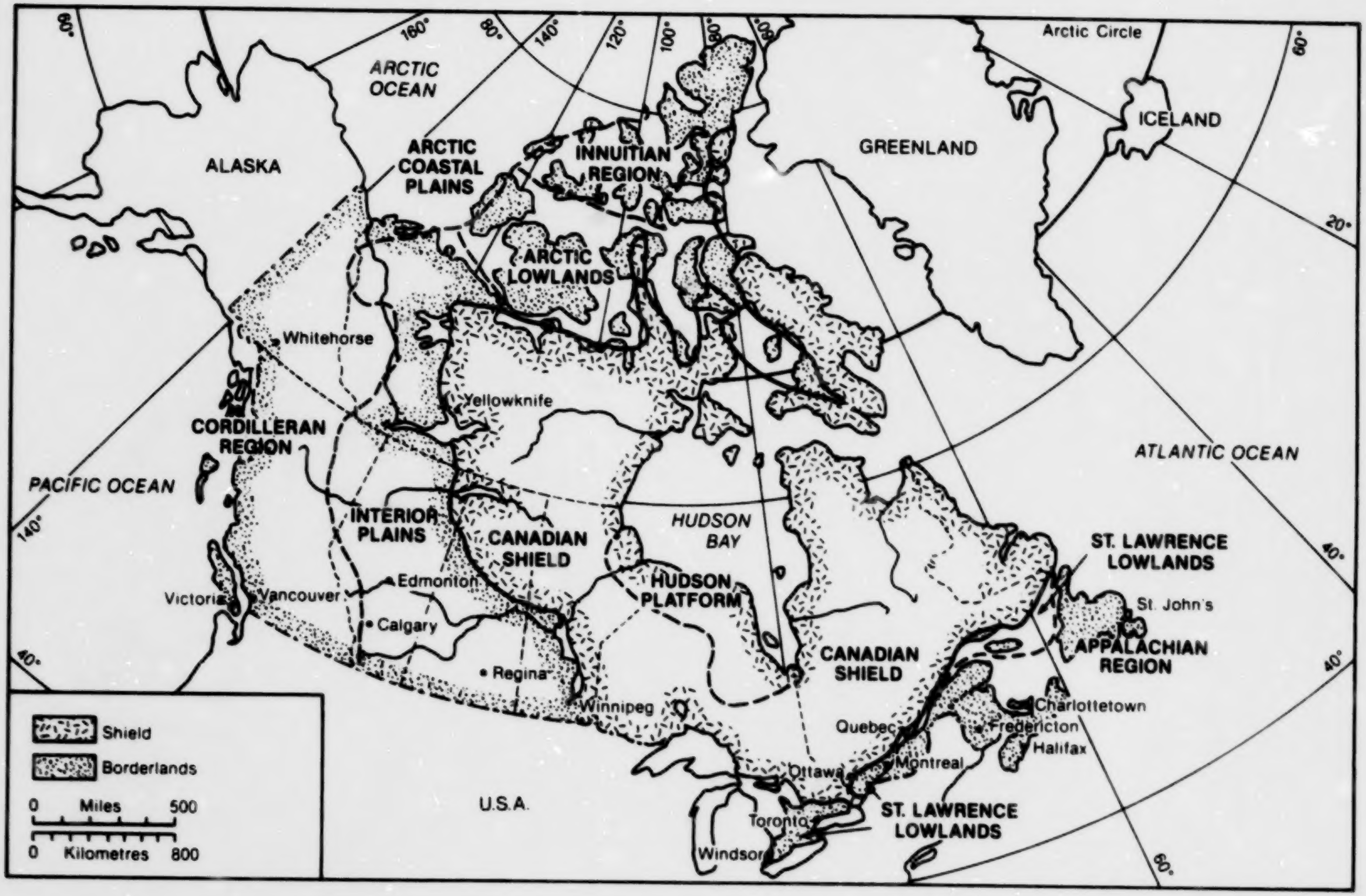
1) the accumulation of soil parent material, primarily by ice and water agents at the time of deglaciation, and

2) the differentiation of the material into soil horizons or layers.

To identify these variations, soil surveys have been completed for the agricultural areas of southern Ontario. Soil maps prepared for each county identify the various soil series and the types of soils that occur within the given series.

Figure 1.1 Physiographic regions of Canada

Source: *Soils of Canada. Vol 1: Soils Report.* Agriculture Canada


60°
160°
80°
140°
120°
100°
80°
60°
Arctic Circle
60°
ARCTIC OCEAN
ICELAND
GREENLAND
ALASKA
ARCTIC COASTAL PLAINS
INNUITIAN REGION
20°
ARCTIC LOWLANDS
Whitehorse
Yellowknife
CORDILLERAN REGION
ATLANTIC OCEAN
PACIFIC OCEAN
HUDSON BAY
140°
INTERIOR PLAINS
CANADIAN SHIELD
ST. LAWRENCE LOWLANDS
40°
Edmonton
HUDSON PLATFORM
St. John's
Victoria
Vancouver
Calgary
CANADIAN SHIELD
APPALACHIAN REGION
40°
40°
Regina
Winnipeg
Charlottetown
Shield
Quebec
Fredericton
Borderlands
Halifax
Montreal
Ottawa
0 Miles 500
U.S.A.
ST. LAWRENCE LOWLANDS
Toronto
0 Kilometres 800
Windsor
60°

As a follow-up to the soil surveys a classification known as the Canada Land Inventory has been designed to group soils that have similar capabilities for a particular purpose (Appendix B). This is considered an interpretative classification because the soils are classified with respect to their ability to produce general field crops. The system does not apply to specialty crops such as fruit and vegetables nor to organic soils.

This classification groups mineral soils with similar limitations or productivities into seven classes. Classes 1 to 3 are considered suitable for sustained production of common field crops. Class 4 is marginal for sustained production of common field crops. Class 5 can be used only for permanent pasture and hay, and Class 6 only for wild pasture. Class 7 has no capability for agriculture. Classes 1 to 4 can be used for pasture and hay as well as for common field crops.

Productivity

If the same level of management is applied to different classes of soils, they will differ in productivity. Relative productivities of different classes are presented in Table 1.1.

For comparison, the figures reported to OMAF by farmers show that approximately 4.2 million hectares of land were involved in the production of crops in Ontario in 1979.

Data on the amount of agricultural land in Ontario are available from a number of sources. Table 1.2 provides the figures from two of these sources and relates these to the six regions of the province (Figure 1.3). The existence in the Northern Region of more than 2 million hectares of land with agricultural potential should be noted.

Drainage

Agricultural land drainage is the removal of excess water from soil in order to increase its agricultural productivity. Over 2.4 million hectares in Ontario can be improved for crop production by the installation of tile drainage.

Figure 1.2 Physiographic divisions of the St Lawrence Lowlands

Source Soils of Canada Vol 1 Soils Report Agriculture Canada

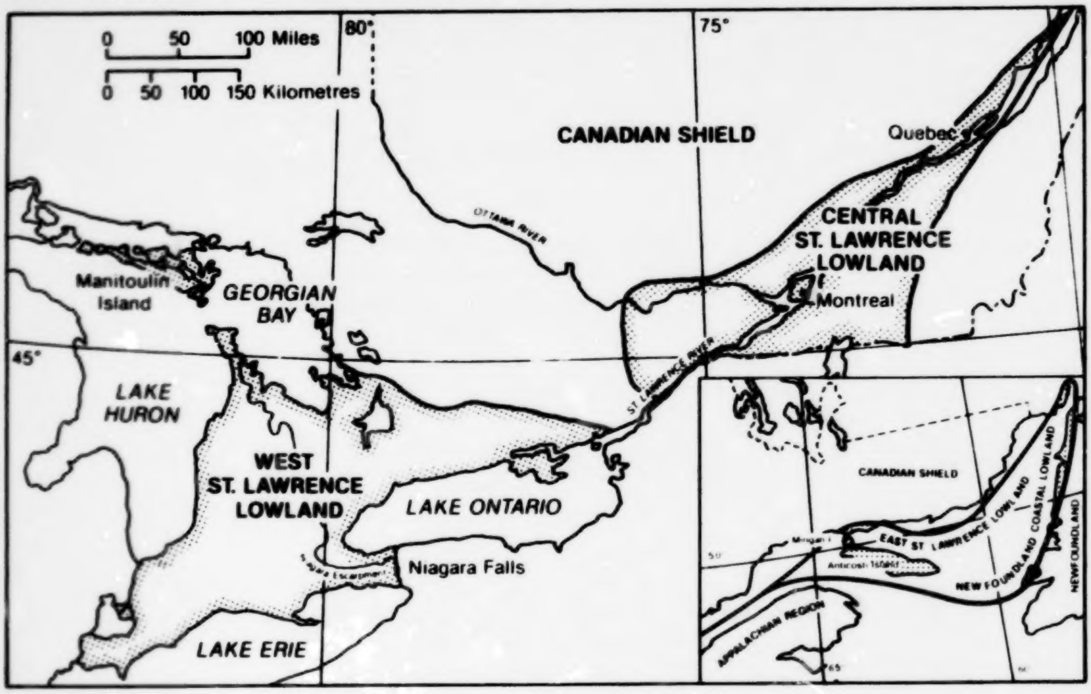

0 50 100 Miles
0 50 100 150 Kilometres
80°
75°
45°
CANADIAN SHIELD
Quebec
OTTAWA RIVER
CENTRAL ST. LAWRENCE LOWLAND
Montreal
Manitoulin Island
GEORGIAN BAY
LAKE HURON
ST LAWRENCE RIVER
WEST ST. LAWRENCE LOWLAND
LAKE ONTARIO
Niagara Escarpment
Niagara Falls
LAKE ERIE
CANADIAN SHIELD
EAST ST LAWRENCE LOWLAND
NEWFOUNDLAND COASTAL LOWLAND
NEWFOUNDLAND
Anticosti Island
APPALACHIAN REGION
65

Figure 1.3 Regional divisions of Ontario

Source Ontario Energy and Agriculture Policy Committee

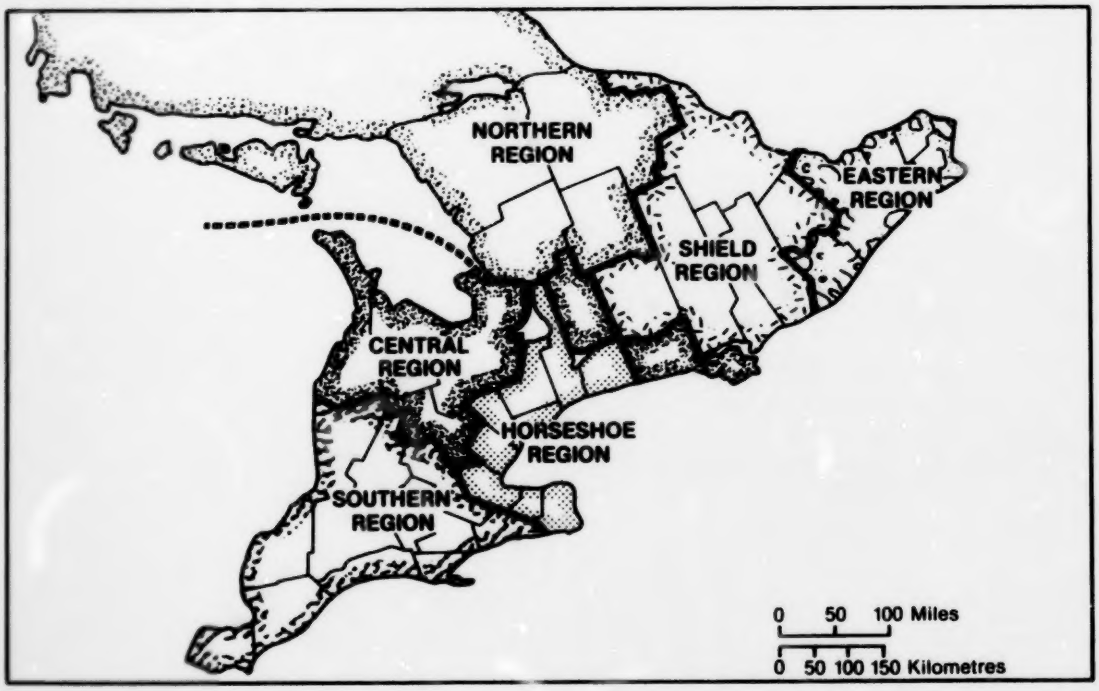

NORTHERN REGION
EASTERN REGION
SHIELD REGION
CENTRAL REGION
HORSESHOE REGION
SOUTHERN REGION
0 50 100 Miles
0 50 100 150 Kilometres

TABLE 1.1

Productivity indices for agricultural soils

Class	Field crop yields
1	1.00
2	0.80
3	0.64
4	0.49

SOURCE: ARDA Report 4, The Assessment of Soil Productivity for Agriculture

TABLE 1.2

Agricultural land in Ontario (thousands of hectares)

	CLI area Classes 1-4	1979 Assessment		1976 Census	
		Farm use	Farmland	Total farm acres	Improved area
Central	1479	1554	1297	1413	1024
Southern	2208	2132	1931	2040	1785
Eastern	691	753	595	632	444
Horseshoe	766	565	509	768	382
Shield	615	661	310	545	238
Northern	2906	988	631	500	409
TOTAL	8665	6653	5273	5898	4282

NOTE: These are gross figures for the hectares that have been identified as potential agricultural lands. They may now be covered with trees or lying idle, but it is assumed that if needed they could be farmed. The data have been collected on the farm to establish the assessed value of the farm for municipal tax purposes. Farm use is a gross figure and includes all the land on the farm including the woodlots. Farmland is the net acres being farmed and excludes the woodlots. Total farm area is a gross measurement, and improved area shows the hectares being farmed.

SOURCE: ARDA Report 8, Acreages of Soil Capability Classes for Agriculture in Ontario (1975); Statistics Canada

Tile-draining of agricultural land improves crop yields through increased aeration of the soil, increased soil temperatures, better soil structure, greater soil bearing strength, faster drying of the soil, improved availability of several plant nutrients, increased water-holding capacity of the soil, and an improved environment for soil bacteria.

Production costs can be reduced with a good drainage system. Applied fertilizer becomes more effective because it is dissolved in the soil moisture and taken up by plants in a properly drained soil. As more water infiltrates into the soil, less water flows off the surface, and erosion is reduced.

Drainage also saves energy because the soil is more easily cultivated, requiring less fuel and fewer passes with field equipment.

Financial assistance to municipalities to construct outlet drains and provide low-interest loans for tiles has been available for some time in recognition of the continuing need to bring potentially productive agricultural land into full production. Assistance to farmers to finance tile drainage was first implemented in 1878. Ontario farmers have utilized the program for financial assistance to install tile drains on over 1.2 million hectares of land since 1878. The rate of installation in 1980 approached 81 000 hectares a year.

Statistics from the Crop Insurance Commission of Ontario provide some insight as to how the yield of a particular crop may be improved with drainage. The average yield of grain corn in Ontario in 1979 on fields with tile drainage was 5.8 tonnes/ha. and without tile drainage 4.2 tonnes/ha. This suggests an Ontario farmer might expect an increase in yield of 1.6 tonnes/ha. if tile drainage were installed, although of course many other factors would be involved in each case.

Finally, drainage allows a greater variety of crops to be grown, making possible greater flexibility for management to respond to changing markets and therefore in the long run to significantly increase farm income.

Climate

World climate has been generally stable over the past century, although there has been a general cooling trend in the northern hemisphere since about 1938 and some climatologists have predicted greater climatic instability during the next thirty years. In general, climatologists find it hard to agree on whether temperatures will rise as the result of increased carbon dioxide in the air, fall as the result of long-term cooling in the world system, or remain steady as the result of the two trends cancelling each other.

Climate in Ontario

In southern Ontario the perennial crop growing season is 25 to 31 weeks long and the average frost-free period from 17 to 26 weeks in length in the arable land areas, whereas in northern Ontario the ranges are 20 to 26 weeks and 10 to 17 weeks respectively. In the north the frost-free period can be much shorter than that. (At Hornepayne - about one hundred miles west of Kapuskasing - in 1941 there was no frost-free season: the last spring frost occurred on July 15 and the first fall frost on the morning of July 16.)

The growing season based on temperatures is only one criterion for comparing the crop production potential of regions. Other climatic factors include expectancy of drought, excess soil moisture at planting and harvesting times, high humidities, air pollution, sunny weather, hot spells in summer, and cold spells and depth of snow in winter. Problems with excess soil moisture during planting and harvesting seasons and cold spells in winter occur more frequently in the north, whereas drought, high humidities, air pollution, and hot spells in summer are a greater problem in the south. Lack of sunny weather probably occurs with about the same frequency in both north and south. The lack of a sufficient number of fine weather days for haying and harvesting is a frequent problem especially in northern Ontario. The northern climate is often described as combining two climates: a clear, dry prairie winter and spring and a wet overcast maritime summer and fall.

The most significant limitation on the productivity of Canada's foodlands is climate, and in this regard southwestern Ontario is unique in Canada. Southwestern Ontario not only possesses the largest single block of Class 1 and 2 land in Canada but also enjoys the longest growing season (between 130 and 153 days), the most dependable growing-season moisture supply, and the most intense and sustained supply of growing-season sunshine. The result is that, while much of the prairie region is restricted to fewer than a dozen crop alternatives because of dryness and temperature, and while the Atlantic region is restricted by excessive moisture, lack of sunshine, and a scarcity of large parcels of continuous cropland, Ontario is Canada's most adaptable agricultural province. This accounts for the rising production levels of Ontario foodland, and it indicates a future ability to shift from one crop variety to another and from existing production and management systems to new and improved ones as domestic and world markets require.

This flexibility in the mix of agricultural crops in response to the market and the ability to move from traditional to modern management, together with rapid urban encroachment on foodland, has brought some dramatic shifts in the distribution of types of farms during the past three decades. Norman Pearson, ('Food Land and Energy Planning', Royal Commission on Electric Power Planning 1976) describes the main trends as follows:

- the loss of the former Lake Ontario fruit and vegetable belt to the urban areas around Toronto;
- the reduction in Niagara fruit belt cultivation from 15 200 hectares in 1940 to 9400 in 1975;
- the reduction of the Georgian Bay fruit growing area;
- the conversion of the fruit and canning-crop belt north of Lake Ontario to horticultural specialties and urban use;
- the emergence of new specialized-crop areas, such as the Alliston potato and tobacco belt, as farmers migrated farther from the city.
- the development of marshlands for vegetable production (Holland, Thedford, Erieau, Pelee) and the movement of early vegetable canning crops to Essex County;

- the expansion of corn acreage to the north and west as a result of new and shorter-season varieties, leading to not only the conversion of pasture and haylands to graincorn production but also the expanded production of silage corn and the growth of Ontario's beef-finishing industry;
- the sharply higher production efficiency in intensive poultry and livestock production near urban markets;
- the sharp decline in production on poorer lands (close to the Canadian Shield and in northern Ontario) which are less adaptable to new and larger equipment and less profitable for more skilled managers.

These shifts underline the necessity to take climatic limitations and soil productivity into account in agricultural planning. As farmers become more mobile, more conscious of the advantages of better soils, warmer climates, and proximity to urban markets, and capable of managing a flexible production plan taking current markets into account, they move out of marginal areas and intensify pressure on the most-favoured foodlands. The result is that the 'reserve lands' of the clay belt become less attractive, even with the high cost of land in southern Ontario. The clay belts (with Class 4 soils, poor drainage, and cool climate) will produce about half the yield per hectare, after drainage, of Class 1 soils in the south; but the energy, fertilizer, and drainage costs will be high and distance from markets further discourages their use. If farm product prices were to fall, the operator would have little management flexibility, since short cropping seasons and long periods of winter feeding of livestock combine with lower crop yields to increase costs for all types of northern agriculture. Although there are limitations to significantly expanding agricultural production on these lands, they can and do fulfil an important role in supplying local markets.

One of the factors that should be taken into account in assessing the future productivity of Ontario foodland is the impact on crop yield of various air pollutants. Farmers in Essex and Kent counties have been phasing out production of white beans in favour of crops less susceptible to air pollution. Damaging effects have also been noted in the Norfolk County area. The most vulnerable crops appear to be white beans, tobacco, and tomatoes.

Mention has been made previously of the number of frost-free days, the hours of sunshine, and the intensity of sunshine. In agricultural terminology these factors are combined into a form of degree-day measurement known as corn heat units (CHU, calculated as the average of the daily maximum and minimum temperatures). A level of 2300 CHU is required before an area is designated as Class 1 under the CLI Classification (see Figure 1.4).

Ontario has an annual precipitation of from 76.2cm to 91.4cm in the southern portion of the province, usually spread throughout the growing season (Figure 1.5).

Water requirements

Water requirements have increased considerably on the modern farm as a result of increased numbers of livestock per farm unit and the dependence upon an adequate water supply to the home and barn for automated equipment.

The following table quantifies the daily requirements for some farm activities:

	Litres/day
Each member of the family (kitchen, laundry, bath)	225 to 685
Producing milk cow (including washing)	68
Dry cow	54
Steer	45
Horse	54
Hog	14
Sheep	9
Chickens (100)	23
Turkeys (100)	54

Some farms also need water for irrigation. In most cases a pond, river, or lake is the source. The use of irrigation in Ontario is primarily for specialty crops requiring more water than the average rainfall will provide.

Figure 1.4 Mean annual heat units available for corn growing season in southern Ontario

Source: D. M. Brown, G. A. McKay, and L. J. Chapman, *Climate of Southern Ontario. Climatological Studies No. 5.* Department of Transport, Ottawa

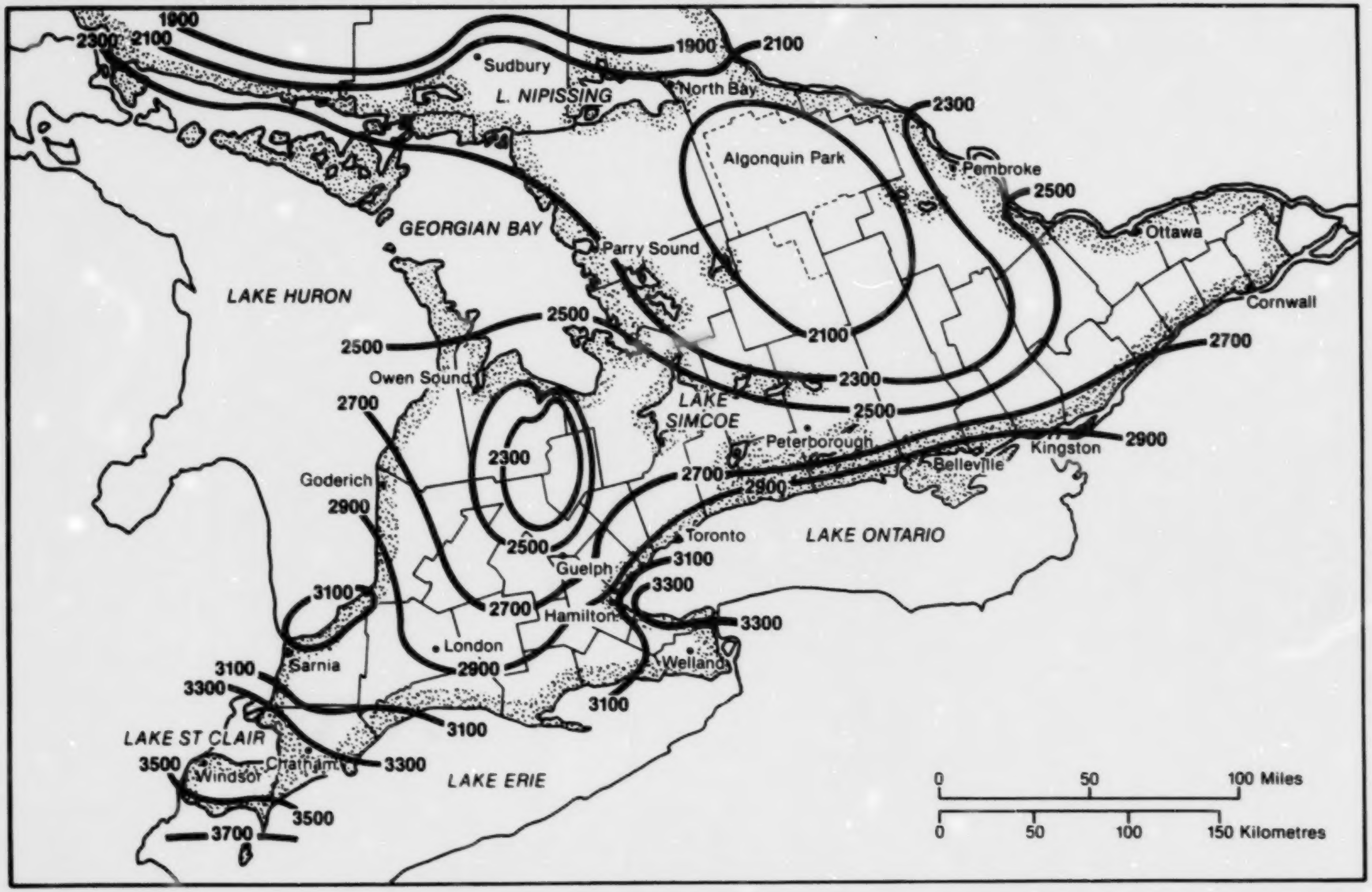
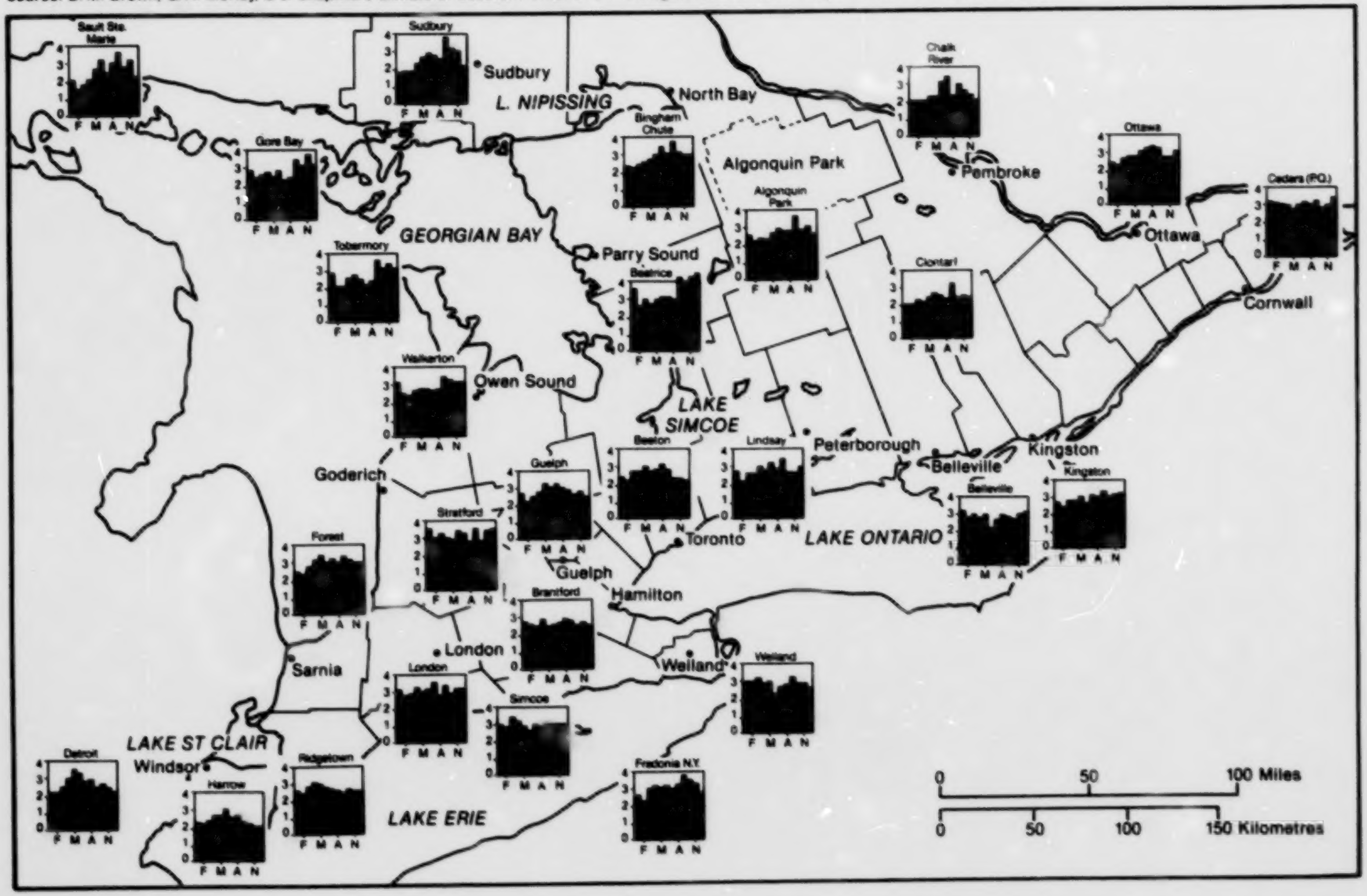

1900
2300
2100
Sudbury
L. NIPISSING
1900
2100
North Bay
2300
Algonquin Park
Pembroke
2500
Ottawa
Cornwall
GEORGIAN BAY
Parry Sound
LAKE HURON
2500
2500
2100
2700
Owen Sound
2300
2500
2700
LAKE SIMCOE
2300
Peterborough
Kingston
2900
Belleville
Goderich
2700
2900
2900
Toronto
LAKE ONTARIO
2500
Guelph
3100
3300
3100
2700
Hamilton
3300
London
Welland
3100
Sarnia
2900
3300
3100
3100
LAKE ST CLAIR
3500
Windsor
Chatham
3300
LAKE ERIE
3500
3700
0
50
100 Miles
0
50
100
150 Kilometres

Figure 1.5 Mean monthly precipitation (inches)

Source: D. M. Brown, G. A. McKay, L. J. Chapman, Climate of Southern Ontario. Climatological Studies No. 5. Department of Transport, Ottawa


Sault Ste. Marie
Sudbury
Sudbury
L. NIPISSING
North Bay
Gore Bay
Bingham Chute
Algonquin Park
Algonquin Park
Chalk River
Pembroke
Ottawa
Ottawa
Cedars (P.Q.)
Cornwall
GEORGIAN BAY
Parry Sound
Tobermory
Beatrice
Clontarf
Walkerton
Owen Sound
LAKE SIMCOE
Beeton
Lindsay
Peterborough
Belleville
Belleville
Kingston
Kingston
Goderich
Guelph
Guelph
Stratford
Toronto
LAKE ONTARIO
Forest
Hamilton
Brantford
London
London
Sarnia
Welland
Welland
Simcoe
LAKE ST CLAIR
Windsor
Detroit
Harrow
Ridgetown
LAKE ERIE
Fredonia N.Y.
F M A N
0 1 2 3 4
0 50 100 Miles
0 50 100 150 Kilometres

As increased demands are placed on the existing water supply there is concern that the lowering of the water table will create problems. The taking of large volumes of water is controlled at present by the Permit to Take Water Program. The Ontario Ministry of the Environment administers the Program under Section 37 of the Ontario Water Resources Act. For many major uses, a permit is required for the taking of more than 45 000 litres of water a day from any source including a well. A permit is not required for the taking of water for domestic and general farm purposes.

The main purpose of the permit legislation is to promote efficient development and beneficial use of water and to prevent and resolve water-supply interference problems.

The taking of water for private domestic and farm purposes is considered the most important use, generally followed by municipal water supply. The taking of water for industrial, commercial, and irrigation purposes is regulated by the availability of the supply, efficiency of use, and established uses in an area.

There is concern in some areas, such as London and Kitchener-Waterloo, about the effect of growing urban areas on farm water management decisions. Because these centres are not located on the Great Lakes, they draw water from a storage reservoir located in the natural watercourses that have their headwaters and drainage basins in the rural areas. This poses two problems: the building of the reservoir often floods farm lands, and the increased concern about the quality of the water in the watercourses may result in pressure on farmers in the way they manage their farms, for example concerning fertilizer and pesticide applications.

Manpower and expertise

The majority of Ontario farms are owned, managed, and operated by families. The size of the family farm operation has increased in the past ten years and is likely to continue to do so.

The manpower needs of the farm have been replaced over the past three decades by machines. Larger units are available that seed, cultivate, harvest, and plough tens of hectares a day. At the same time new mechanization has been incorporated into the feeding of livestock, the storage of feed, and the preparation and movement of feed to livestock, manure-handling, and milking systems. These changes allow an individual farm worker to feed about eighty people in 1981. This compares with a 1 : 50 ratio in 1960s and a 1 : 30 ratio in the 1950s.

The 1976 Census showed a total of 88 800 farmers, with 56 700 full-time, 16 300 part-time, and 15 750 hobby farmers. The proportion of part-time farmers is fairly constant, but the people who are involved move in and out at a greater rate than those who are farming full-time. Farm employees are most frequently found on livestock farms where their usual responsibility is as herdsmen. In the fruit and vegetable growing areas seasonal workers are brought in from outside the country on special work permits to help grow and harvest these crops.

Farm input supply

There are two aspects to the farm input supply sector: the supply of the basic products to the suppliers and the supply system to the farmers.

Fertilizer is used extensively in Ontario, and the basic elements, potash and phosphorus, are obtained from the United States or western Canada. Nitrogen is manufactured from natural gas in Canada.

Pesticides and herbicides are also used, many of them imported from the United States.

Fuel, now primarily diesel, is required to power tractors and other equipment used to plant, harvest, and process farm crops. This too comes from outside Ontario.

The machinery used to produce crops may be manufactured in Ontario or imported. There are many makes of machinery and a vast network of dealers in Ontario.

Twine used in baling hay is either plastic, which is produced in Ontario, or of the older type, which is imported.

Some seed is brought into Ontario, but Ontario now produces a great deal of seed, and capacity is being expanded.

In the past most rural towns had a feed mill, a hardware store, a farm fuel supplier, and in some cases a fertilizer distribution point. In many cases the services provided by these individual enterprises have joined together as a farm supply outlet.

There has been a very considerable rationalization in the farm machinery industry. Small dealers have disappeared, and now it is common to travel more than a hundred kilometres for parts for a particular machine. The fact that a reliable dealer is available nearby is often the deciding factor in the purchase of a new farm machine.

Custom operators provide a valuable service to the farm community and frequently offer such services as silo filling, combining, ploughing, and spraying.

In general the needs of Ontario agriculture are adequately supplied, although the farm supply system is finding it difficult to cope with the volume of the demand peaks, most evident at seeding time.

Storage capacities

There has been a trend in recent years to on-farm storage of a wide range of farm produce, fruit, vegetables, grain, and hay.

In fruit and vegetables, storage with atmospheric control allows for the marketing of these products over an extended period after the harvest. It also enables the producer to carry the product one or two steps closer to the consumer and therefore receive a higher gross return.

On grain and livestock farms, a range of crop storages are available. Harvested grain is stored in 10-20 000 bu. bins, which may be equipped with either ambient or heated-air ventilation. On-farm grain drying centres allow crops harvested in the fall to be dried before they are moved to storage.

On-farm stored-feed structures are a major component of livestock farm systems today. These structures may be sealed silos (steel, glass-lined, or concrete), open silos (slab or poured concrete), bunker silos, (in-ground or above-ground), or simply concrete pads on which the stored feed is piled.

A number of crops are stored in these silos at various stages of maturity and moisture levels. These crops include alfalfa or alfalfa-grass as haylage, whole plant corn silage, high moisture shelled corn, corn and cob meal, high moisture barley, and oats.

In combination with various storage facilities, feed rollers, grinders, mixers, and blenders are available for the preparation of farm rations on the farm.

Off-farm storage is also increasing because the marketplace demands a regular supply at a volume that cannot be provided by an individual producer. Ontario is also moving into the export of grain. The larger off-farm storage systems assemble, clean, grade, and ship, by rail, truck, or ship for domestic and export use.

Ontario farm storages are planned as annual storages. In general there is no carryover of crop in storage.

CURRENT PRODUCTION OF FOOD IN ONTARIO

Agriculture in Ontario encompasses a wide variety of activities including dairying, poultry farming, livestock raising, and the production of fruit, vegetables, and field crops. Though Ontario's share of total Canadian farm cash receipts declined from about 33 per cent of the national total in 1970 to about 28 per cent in 1979, Ontario still shows by far the largest income from farming operations among the Canadian provinces.

Agricultural income in Ontario can be roughly divided into two major segments: crop production, and livestock and its products (Table 1.3). In addition, a number of federal or provincial programs contribute supplementary payments. Figure 1.6 to shows the sources of farm income in Ontario.

Figure 1.6 Sources of farm income in Ontario

Note: Other crops include fruit, vegetables, greenhouse vegetables and mushrooms

Source: Agricultural Statistics for Ontario, Ministry of Agriculture and Food

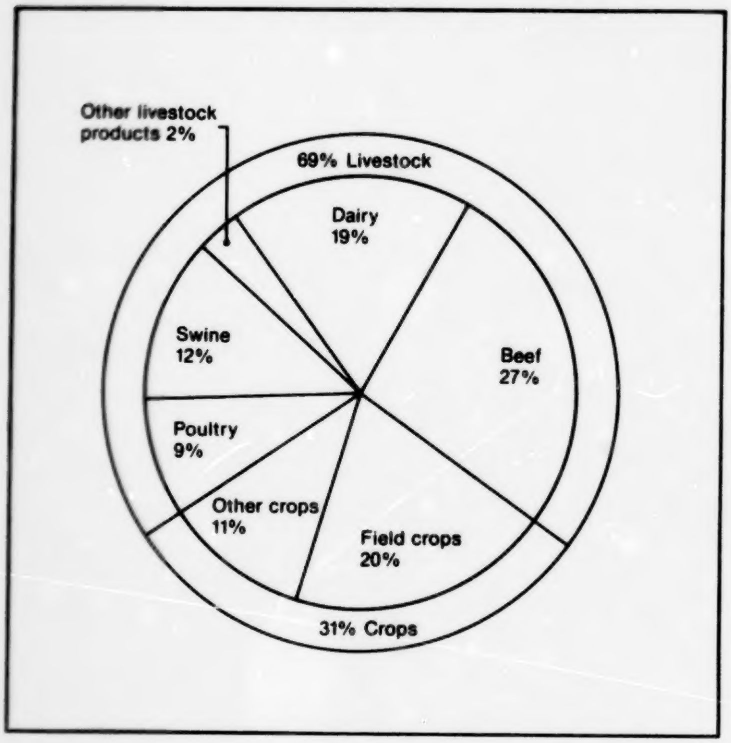


TABLE 1.3

Farm cash receipts from farming operations, 1970-80

Product	1971-5 (annual average)	1975	1976	1977	1978	1979	1980
Field crops[a]	208.6	291.1	332.6	343.2	396.4	486.0	681.3
Other crops[b]	411.4	332.8	353.4	361.5	348.8	405.4	456.1
Poultry and eggs	221.0	252.7	285.4	288.5	316.2	373.7	391.9
Swine	229.6	304.4	297.8	285.7	399.1	452.7	467.4
Dairy[c]	405.1	541.3	565.3	594.7	605.7	681.8	790.5
Beef	493.0	602.3	572.4	668.6	903.6	1109.6	1116.6
Other livestock products	25.6	32.3	33.2	36.8	38.0	54.3	59.8
Total food	1994.3	2356.9	2440.1	2579.0	3007.8	3563.5	3963.6
Other agriculture							
Tobacco	156.4	186.4	220.8	169.2	253.2	273.6	196.2
Nursery & floriculture	44.0	86.5	101.8	105.2	115.0	120.7	143.7
Total agriculture	2194.7	2629.8	2762.7	2853.4	3376.0	3957.8	4303.5

a) Includes crop insurance payments

b) Includes fruit, vegetables, mushrooms, greenhouse vegetables, maple products

c) Includes dairy supplementary payments

SOURCE: Agricultural Statistics of Ontario, Ministry of Agriculture & Food

The most important Ontario food crop is corn, which accounts for more than 8 per cent of total farm cash receipts. Corn was produced on a total of 1 121 000 hectares, of which 810 000 were grain corn, the remainder fodder corn.

Other feed grains grown in Ontario are barley, oats, and mixed grains. Vegetable production in Ontario accounted for almost 5 per cent of agricultural cash receipts. More than half of Ontario's vegetable production is processed. The largest vegetable crop is tomatoes, with more than 90 per cent being delivered to the processing industry for canning.

Though cash income and associated expenses show an increase, partly on account of inflation, agricultural production in general has levelled off in the past three years.

CURRENT IMPORTATION OF FOOD INTO ONTARIO

Over the past seven years, Ontario's agricultural imports have more than doubled in value. During 1980, the value of agricultural imports totalled $2.3 billion. The value of non-replaceable agricultural imports in 1979, at $799 million, was up 165 per cent over 1973. In 1979 raw sugar, green coffee, cocoa beans, raw cotton, fresh and processed oranges, and fresh bananas accounted for more than $327 million, or 41 per cent, of the non-replaceable total imports, up from $114 million in 1973.

Replaceable agricultural imports were $1.25 billion in 1979, as against $0.6 billion in 1973. Animal products, fruits and vegetables, beverages, and grains accounted for 57 per cent of the 1979 replaceable total imports.

From 1973 to 1980, Ontario's agricultural exports more than doubled in value to reach $1.3 billion. The United States imported more than 53 per cent of Ontario's agricultural exports, and the European community imported 21 per cent. Exports to Japan accounted for 5 per cent.

In the 1970s Ontario's agricultural trade balance turned from negative to positive for live animals, meats, and grains (Table 1.4). The trade balance in dairy and poultry remained negative. Fruit and vegetable imports have increased through more imports of non-replaceable foods as well as increased off-season imports of foods produced in Ontario.

TABLE 1.4

Ontario trade balance of agricultural products, 1973-79 ($000)

	1973	1974	1975	1976	1977	1978	1979	1980
Live animals	-48,318	-27,908	-21,069	-39,482	+1,658	+10,158	+52,207	+7,452
Meats	+10,147	-14,618	-23,059	-76,462	-48,703	-38,400	+13,437	+53,464
Poultry & eggs	-161	-5,371	-7,226	-26,582	-17,661	-17,998	-25,622	-2,859
Dairy products	+2,351	-15,668	-17,922	-13,972	-18,766	-9,520	-13,883	-8,125
Other animal products	-7,852	-21,245	-11,726	-13,653	-10,027	-9,484	-21,532	-37,297
Grains	-36,159	-52,402	+8,258	+53,952	+21,205	+47,298	+2,091	+82,633
Grain products	+17,797	+21,576	+33,976	+14,708	+8,146	+22,231	+25,393	+36,736
Animal feeds	+14,020	+9,002	+3,863	+8,162	+9,343	+9,316	+24,124	+27,299
Fruits and nuts	-154,604	-172,087	-185,954	-217,585	-261,199	-314,203	-373,864	-398,341
Vegetables	-31,901	-48,424	-47,669	-50,962	-72,157	-103,348	-107,467	-92,954
Potatoes	-5,355	-6,163	-3,862	-8,118	-9,511	-8,611	-8,078	-6,272
Seeds for sowing	-7,022	-9,269	-8,864	-11,515	-18,401	-19,769	-31,080	-28,823
Oil seeds	-54,223	-100,038	-99,670	-93,502	-105,727	-91,300	-121,507	-132,069
Oil seed products	-42,599	-80,833	-77,359	-83,393	-101,471	-122,624	-152,776	-115,843
Vegetable fibres	-19,567	-22,749	-18,079	-22,081	-22,036	-21,894	-24,902	-31,721
Plantation crops	-74,534	-72,842	-91,380	-91,826	-180,692	-204,586	-243,812	-241,082
Spices	-3,564	-4,338	-3,745	-4,622	-6,046	-7,989	-7,149	-7,716
Sugar & related products	-26,521	-99,365	-135,163	-94,903	-57,558	-40,394	-63,642	-232,849
Confectionery	-5,708	-14,369	-20,195	-19,154	-23,427	-22,521	-25,941	-19,262
Nursery stocks	-7,697	-10,073	-14,629	-16,870	-18,644	-18,752	-21,151	-20,647
Beverages	+120,116	+61,929	+121,986	+113,934	+135,999	+110,659	+131,260	+167,267
Tobacco	+49,361	+63,969	+56,761	+55,819	+55,189	+88,050	+126,865	+39,206
Other agric. products	-26,285	-31,159	-33,780	-38,803	-40,452	-44,057	-43,466	-48,531
TOTAL	-348,278	-652,445	-596,507	-676,910	-780,938	-807,738	-910,497	-1,010,334

NOTE: Live animals excludes live poultry (included in Poultry & eggs) and honey bees (included in Other agricultural products).

SOURCE: Statistics Canada, External Trade Division and Economics Branch, Ontario Ministry of Agriculture and Food

The deficit in oilseed trade has increased, with exports actually dropping on a volume basis.

Meat exports, mainly to United States, totalled $152 million in 1980, a fourfold increase from the $35 million in 1974. The United States imported about one-third and the European community about 29 per cent of Ontario's livestock and animal products exports. Grain exports accounted for $190 million in 1980, an eightfold increase over 1974. Beverage exports, mainly to the United States, totalled $265 million in 1980.

Tobacco exports reached a record value of $140 million in 1979, of which the United Kingdom imported $83 million.

ENERGY REQUIREMENTS OF FARM PRODUCTION IN ONTARIO

Detailed energy inputs of farm production in Ontario have been developed for twenty-seven major Ontario field crops and six animal products (Research Report 1). These crops, shown in Appendix C, cover about 89 per cent of the total cash value of crop output in 1980 excluding tobacco, and the animal products cover 98 per cent of the value of output. The data are therefore comprehensive and provide an excellent picture of energy use by crop type. Most of the data are for 1978, but the energy input values should remain accurate for several years until prices and technology force a change in the mix of inputs to various crops. Hence, as a tool for short-term analysis, the 1978 data can be considered adequate.

All types of energy used in production have been accounted for, including off-farm production of fertilizers and pesticides, on-farm production of energy, and off-farm transport for delivery of output to market. Figure 1.7 shows the breakdown of energy expenditure by farm product, and Figure 1.8 summarizes energy expenditures by farm activity.

Energy consumption for crop production

Appendix C shows the total energy consumption by crop type and fuel type in 1978, and Table 1.5 summarizes the costs of energy as a percentage of total costs. The appendix shows a total of $101.3 million was spent on energy for production of the crops included in this report. A further $11.5 million was spent for crop transportation (Table 1.7 below).

Figure 1.7 Energy dollar expenditure in Ontario food production (1978)

Note: Other crops include fruit, vegetables, greenhouse vegetables and mushrooms

Source: Research Report 1

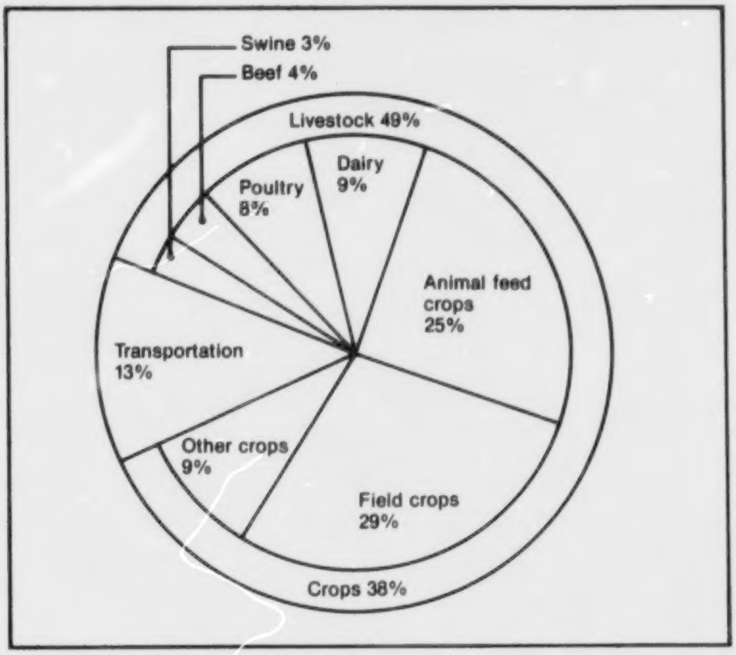


Figure 1.8 Energy dollar expenditure in Ontario by farm activity (1978)

Source: Research Report 1

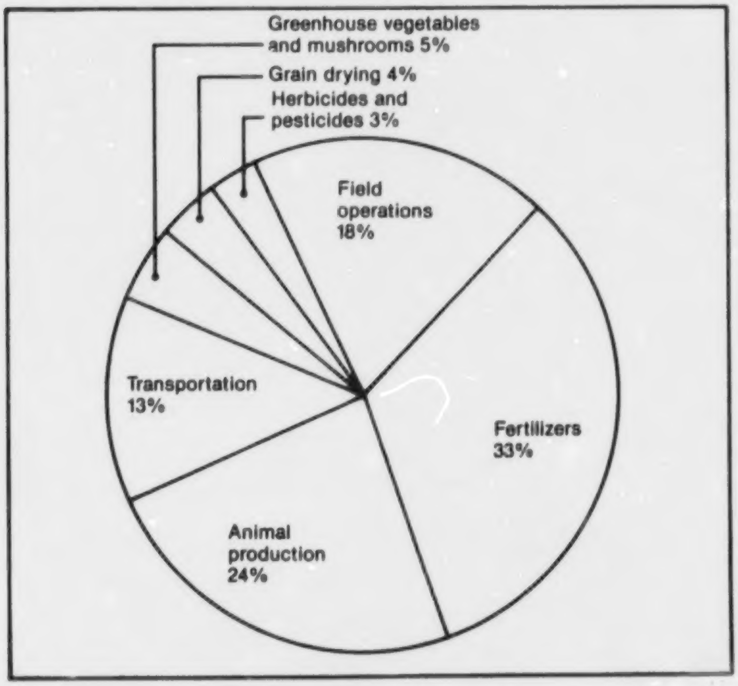


TABLE 1.5

Energy costs as percentage of production costs per hectare for Ontario crops, 1978

CROP	Energy costs ($)	Essential material input costs (EMI) ($)	Total production costs ($)	Energy as percentage of:	
				EMI (%)	Total costs (%)
Barley, mixed grains	7.68	50.67	130.70	15.2	5.9
Oats	6.01	43.28	139.19	13.9	4.3
Winter wheat, rye	9.79	58.79	184.76	16.7	5.3
Grain corn	20.00	93.05	269.80	21.5	7.4
Silage corn	16.88	75.48	220.65	22.4	7.7
Soybeans	6.29	54.60	215.70	11.5	2.9
White beans	6.74	71.22	201.83	9.5	3.3
Haylage, hay	7.16	39.20	153.53	18.3	4.7
Pasture	3.94	19.60	52.06	20.1	7.6
Apples	25.08	339.67	1382.81	7.4	1.8
Grapes	22.68	215.12	1229.13	10.5	1.8
Peaches	18.42	746.80	1923.05	2.5	0.9
Cabbage, cauliflower	30.65	726.13	1647.67	4.2	1.9
Carrots	30.36	540.51	1416.51	5.6	2.1
Celery	42.09	1132.37	3827.31	3.7	1.1
Cucumbers	20.58	175.15	1924.34	11.7	1.1
Sweet corn	14.25	123.74	282.79	11.5	5.0
Lettuce	22.13	894.67	2323.24	2.5	0.9
Onions	30.96	849.67	1904.93	3.6	1.6
Peas	7.81	205.40	356.81	3.8	2.2
Potatoes	32.62	307.17	615.37	10.6	5.3
Rutabagas	18.30	186.46	785.31	9.8	2.3
Tomatoes - fresh	29.19	1160.30	3778.00	2.5	0.8
Tomatoes - processing	23.60	323.36	1156.43	7.3	2.0
Mushrooms (cost per kg)	0.17	0.55	1.66	31.0	10.2
Average (excl m'rooms)				10.3	3.3
Range (excl pasture and m'rooms)	6.01-42.09			2.5-22.4	0.8-7.7

SOURCE: Research Report 1

Energy use can be divided into three main categories for crop production: pesticide production, field operations, and fertilizer manufacture and delivery. Grain drying is a fourth energy use in the case of corn. Appendix D shows that the relationship between these categories varies, with fertilizer energy costs taking precedence in crops such as grain and silage corn, winter wheat, and tomatoes, as opposed to cabbage and cauliflower, carrots, cucumbers, and peas, for which field operations require most energy. Fertilizer and field operation costs are roughly equal for soybeans, white beans, hay, oats, lettuce, potatoes, and rutabagas.

Herbicides and pesticides

The importance of energy supply for pesticides cannot be overlooked, and total energy costs per acre for these materials can be quite high, as with grapes ($5.15, or 23 per cent of production energy costs) and onions ($7.39, or 24 per cent of production energy costs). A disruption of energy supply for fertilizer production could be partially circumvented by increased use of green manures and better use of animal manures. However, there is no ready substitute for pesticides, and the effects of an interruption of supply would be quickly perceived.

The situation with respect to pesticide energy requirements is further complicated by the fact that most of the energy for pesticide production is consumed outside Canada (i.e. at higher world energy prices), so that while the energy consumption data for pesticides are felt to be accurate, the energy cost data are undoubtedly lower than actual fact, since Ontario prices were used. The higher world prices are, of course, reflected in the selling price of pesticides, and therefore the energy cost of pecticides occupies a greater portion of total production energy costs than indicated.

The energy for pesticide production (much of which is consumed in Canada and the United States) is shown in Appendix C in terms of gasoline equivalent (specific consumption by fuel type is not available). It is worthwhile to note that an estimated 472 TJ are used for pesticide production, compared to a total of 1037 TJ of gasoline for all other agricultural purposes, including field operations, fertilizer manufacture and delivery, and pesticide synthesis. There is an extremely large range in energy costs for pesticide production, and emulsifiable concentrates are very high in energy cost.

Field operations and fertilizer

It can be seen in Appendix C that hay and haylage together account for about 37 per cent of all diesel fuel for crop production, with grain and silage corn requiring another 30 per cent. It is estimated that approximately 55 per cent of all farm tractors in the United States are diesel-powered, and a similar situation exists in Ontario. However, these diesel tractors perform 80 per cent of all field work, primarily because of their higher horsepower and, to a lesser extent, their higher utilization levels. Since the trend towards diesel engines for tractors and combines (and swathers) is persisting, the per-hectare diesel fuel requirement will increase as gasoline units are replaced.

Natural gas and diesel fuel expenditures for crop production are almost equal. Over half of the natural gas expenditure goes to grain and silage corn production (primarily for fertilizer materials), and this amount (for corn alone) is greater than the combined expense for gasoline, propane, and electricity for all crops.

The single largest total energy expense (on a per-crop basis) is for the production of grain corn. Corn harvested for grain and silage entails a total energy cost of $47 million, or 47 per cent of all money devoted to energy for production of the crops included in this report. Corn and hay account for 68 per cent of total crop production energy costs. In contrast to this, all of the fruit and vegetable field crops combined (including potatoes) require the use of $2.7 million in gasoline and diesel fuel - or about 6 per cent of the total gasoline and diesel expenditure. From an energy point of view, therefore, grain and silage corn and hay are by far the most important, though they represent a much lower proportion of farm cash receipts. However, these crops are crucial for livestock production, the sector generating the greatest farm cash receipts in the province.

The importance of energy-related fertilizer for some crops should be noted. Appendix D shows the details for each crop. Table 1.6 summarizes some of the crops where fertilizer makes up more than 50 per cent of the total cost of production. All kinds of corn and small grains have greater than 50 per cent of total costs in energy-based fertilizers, while there are only three field crops of vegetables that have fertilizer costs above 50 per cent. The fact that pasture has a high proportion of fertilizer costs reflects the low total cost of pasture maintenance.

Energy costs as a percentage of production costs

One peculiar aspect of Table 1.5 is that energy costs (per acre) are generally greatest in the case of crops for which energy represents the smallest percentage of total production costs. Thus, while an energy expense of $7.68 for barley accounts for 5.9 per cent of total production costs, a much larger outlay of $42.09 per acre of celery represents only 1.1 per cent of the total production costs. This is very significant, because a response to increasing energy prices will be very different from a response to energy supply shortages, i.e. a celery producer will tend to disregard even a large energy price increase, since it will augment production costs only slightly, but a supply shortfall would necessitate finding a replacement or substitute for twenty-four gallons of gasoline for each acre of celery.

TABLE 1.6

Distribution of total crop production costs (crops with fertilizer input more than 50 per cent of cost of production, percentages)

Crop	Fertilizer	Field operations	Pesticides	Total
Oats	57	41	2	100
Winter wheat	68	32	-	100
Grain corn	55	15	8*	100
Silage corn	65	25	10	100
Pasture	86	14	0	100
Celery	52	38	10	100
Sweet corn	64	27	9	100
Tomatoes (fresh)	60	28	12	100
Tomatoes (processing)	51	35	14	100

*Drying of grain corn is 22 per cent.

SOURCE: Research Report 1

As shown in Table 1.7, transportation energy costs for the major crops totalled about $11.5 million in 1978, equal to 10 per cent of the sum of transportation and production energy costs. Energy costs for crop transportation are approximate, since firm data for fruits and vegetables are not available. Appendix E shows the assumptions used in the calculations.

Generally, transportation when expressed as a percentage of total energy costs is inversely related to moisture content. For example, root crops and lettuce require much more fuel for transportation than white beans, soybeans, and corn. Transportation in this study is to first destinations, e.g. to dryers and country elevators for grain corn, and to the vegetable terminal or to warehouses adjacent to urban areas in the case of lettuce. Typical hauling distances are shorter for most grain crops than for fruits and vegetables. In spite of this fact, the total energy expenditure for transporting grain corn is the largest of all the crops in the study, with some $2.3 million being spent on transport fuel in 1978.

Energy consumption for animal production

Energy is required for three main purposes in animal production: on-farm (for brooding, ventilating, manure handling, feed grinding, milk cooling, etc.), commercially manufactured feeds (mainly for monogastric species), and transportation (primarily to processing plants). Appendix F gives energy consumption for animal production on a per-unit basis, and Appendix G describes total energy consumption for animal production in 1978. In the case of poultry, the fuel per bird is a composite weighted average, since birds are brooded using electricity, fuel oil, natural gas, or propane. Brooding energy constitutes the largest energy component for those monogastric species which are comparatively short-lived, such as chicken broilers, whereas energy for feed manufacturing is the largest input for layer hens.

The overwhelming importance of electricity for dairy cattle is very clearly demonstrated in Appendix G (30 per cent of all animal production energy expenditures). This fact, coupled with the fact that a reduction of electricity consumption for water heating on dairy farms is both technically possible and economically viable, indicates the potential for energy conservation in this area.

TABLE 1.7

Transportation energy costs of crop products in Ontario, 1978

Crop	Total transportation energy expenditure		Transportation energy as a percentage of total energy costs
	TJ	($000)	
Barley, mixed grains	183	1103	11.6
Oats	23	454	13.6
Winter wheat, rye	61	370	8.8
Grain corn	385	2334	6.7
Soybeans	43	256	6.9
White beans	6	38	4.0
Apples	101	593	44.5
Grapes	44	260	31.6
Peaches	20	120	39.0
Cabbage, cauliflower	47	281	64.1
Carrots		262	69.0
Celery	10	58	73.0
Cucumbers	27	164	57.1
Sweet corn - fresh	5	33	28.0
Sweet corn - processing	108	639	55.6
Lettuce (field lettuce only)	13	73	71.9
Onions	51	245	60.3
Peas	200	1185	86.7
Potatoes	205	1173	44.4
Rutabagas	40	235	77.5
Tomatoes - fresh	5	34	31.1
Tomatoes - processing	27	1572	73.2
Total	1540	11482	8.6

* 87 per cent gasoline, 13 per cent diesel

SOURCE: Research Report 1, Tables I.4.1, I.4.2

Many poultry production units, particularly turkey operations, employ gaseous fuels for brooding, with some $2.8 million of propane and $900,000 worth of natural gas being used for this purpose. Since most of the propane-fired units are not serviced by a natural gas pipeline, there is no readily available substitute for this brooding fuel should a disruption in propane supply occur. Diesel fuel is the second largest energy expenditure for animal production, and delivery of manufactured feeds accounts for about $2.7 million, or 33 per cent of the total $8.2 million diesel fuel expense.

Energy costs as a percentage of production costs

Table 1.8 gives energy costs as percentage of production costs for animal commodities. In the case of dairy cattle, energy constitutes about 7.5 per cent of the cost of essential material inputs, the highest of all animal production categories. Energy costs amount to 4.6 per cent of the total costs of production for chicken broilers. This is the highest percentage of total cost of all of the animal commodities. Further detail for each animal commodity is shown in Appendix H.

TABLE 1.8

Energy costs as a percentage of production costs for animal commodities in Ontario, 1978

		Energy cost as percentage of:	
Energy commodity	Energy cost	Essential material inputs	Total production costs
Milk	$24.24 (per 3727 kg)	7.5	4.3
Beef	$ 4.67 (per steer)	2.8	2.2
Pork	$ 2.53 (per finished hog)	3.5	2.1
Eggs	$41.40 (per 2000 dozen)	4.7	3.0
Sheep	$ 0.42 (per ewe)	0.6	0.5
Poultry:			
Chicken broilers	$65.03 (per 1000 birds)	5.9	4.6
Turkey broilers	$20.84 (per 100 birds)	4.9	4.4
Heavy turkeys	$28.68 (per 100 birds)	3.4	3.0
AVERAGE		4.0	3.0

SOURCE: Appendix H

Transportation energy costs

Table 1.9 describes fuel consumption and energy costs for livestock transportation. The cost of fuel for transportation of livestock in 1978 totalled approximately $10.4 million, or one-quarter as much as the cost of production. Transportation energy costs represented as much as 40 per cent of the total energy expenditure in the case of beef cattle and as little as 7 per cent for turkey broilers. Transportation costs are paid for directly by the farmer in some instances (e.g. milk, beef), but in other cases (e.g. broiler chickens) these costs are absorbed by the processor. The transportation of eggs and fowl accounts for 37 per cent of the total energy expenditures for egg production. During consultation with the Ontario Egg Producers' Marketing Board, the view was put forth that a significant reduction in fuel use could be achieved primarily by resorting to a more rationalized grading station pick-up system (i.e. one grading station servicing one route or area), along the lines of the procedures employed by the Ontario Milk Marketing Board. According to the Egg Board, considerable overlap and unnecessary duplication exists, and although no firm data have been compiled, the Egg Board expressed a willingness to provide the required information for such an undertaking.

There is a wide range of transportation energy costs for beef production in Ontario. In the worst case, a total of 3020 MJ (about 66.0 litres of diesel fuel) are used to transport the animal during its lifetime, compared to 142 MJ (3.2 litres of diesel fuel) for the best case (domestic production). Since, as previously mentioned, transportation energy costs represent such a large portion of total energy expenditures for beef, the need for an additional pathway for reduced fuel consumption is apparent.

TABLE 1.9

Transportation energy costs of animal commodities in Ontario, 1978

Animal Commodity	Fuel consumption (L) (diesel + gasoline)	Cost	Sum of production and transportation energy costs*	Transportation energy cost as percentage of sum
Milk	3.1 + 15.7 (per 3727 kg)	$3.97	$28.21	10.4
Beef	7.6 + 7.2 (per slaughter animal	$3.08	$7.75	39.7
Pork	0.45 + 1.35 (per finished hog)	$0.38	$2.91	13.1
Eggs (and fowl)	112.0 (2000 dozen eggs + 100 fowl)	$23.75	$65.15	36.5
Poultry: Chicken broilers	6.0 (per 1000 birds)	$5.52	$70.55	7.8
Turkey broilers	6.0 (per 1000 birds)	$14.72	$223.12	6.6
Heavy turkeys	27.0 (per 1000 birds)	$24.84	$311.64	8.0

*production energy costs as shown in Table 1.8

SOURCE: Research Report 1

AGRICULTURE PRODUCTION PROJECTIONS

Population growth rate 1980–1985–2000

The projected average growth rate for Ontario's population from 1980 to the year 2000 is 0.8 per cent a year (Table 1.10 and Figure 1.9). The growth curve is not a straight line but decreases towards the year 2000. The projection is somewhat lower (1.3 million) than those made in the early 1970s. The lower forecast is due to a decline in the birth rate and a shift in Canada's population to the western provinces.

Using the above population forecasts it is possible to project the rate at which domestic food requirements will change over the next twenty years. Domestic population requirements are used in this paper as the basic determinant of our food production system. Other factors, such as export demand, import replacement, and changing consumer preferences, also influence the structure of production. In attempting to project this structure a 'status quo' system has been assumed. This postulates that consumer preference will remain relatively constant and that Ontario will maintain its present level of food self-sufficiency with respect to imports and exports.

The following section shows the expected structure of Ontario agriculture in 1985 and 2000. The available land base and productivity increases are considered later, so that we may project the energy demand of agriculture in 1985 and 2000.

Agricultural production projection 1985–2000

As stated, it has been assumed that food requirements will continue to reflect current consumption patterns and that agriculture in Ontario will expand in order to maintain the current level of food self-sufficiency for a population projected to increase at an average of 0.8 per cent a year over the next twenty years.

Certain external factors will permit these levels of production and influence the farmers' decisions on what commodities to produce.

TABLE 1.10

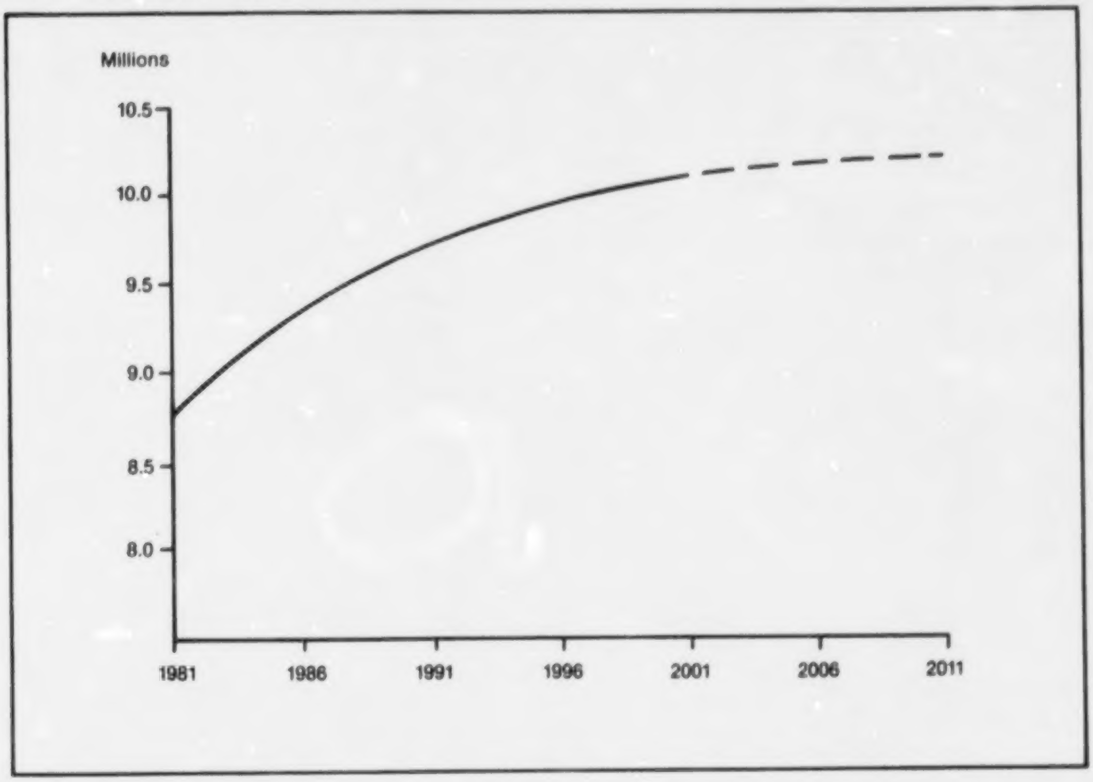
Ontario population forecast by region, 1981-2001

	Estimated population (thousands)				
Region	1981	1986	1991	1996	2001
Eastern	1 203	1 256	1 304	1 339	1 364
Central	5 377	5 694	5 987	6 243	6 461
Southwestern	1 304	1 364	1 422	1 473	1 516
Northeastern	615	651	686	715	738
Northwestern	244	255	266	275	282
Total Ontario	8 743	9 220	9 665	10 045	10 361
Annual growth rate (%)	1.06	0.96	0.77	0.62	

SOURCE: Ontario Ministry of Treasury and Economics

Figure 1.9 Projected growth of the Ontario population

Source: Ontario Energy and Agriculture Policy Committee



In determining the land base and energy inputs necessary for the specified food requirements in 1985 and 2000 compared to 1980, it must be assumed that agricultural productivity will change. Therefore the land requirements for the production of the same quantity of agricultural goods must reflect potential new developments in technology, genetics, and management practices (Appendix I).

Productivity increases in agriculture since the second world war have been substantial. Some studies have indicated a potential for continued technological changes in agricultural production for yield increases to average 1 to 2 per cent annually from 1980 to 2000 in North America. On the other hand many scientists and economists are less optimistic. However, modest gains seem sure to be achieved in certain commodities over the period under study. Table 1.11 summarizes what the Committee believes to be realistic estimates of these potential gains.

A major factor determining the production levels of many commodities in Ontario is the supply management systems under which they are marketed. Given adequate production capability and limited export potential, these commodities cannot be expected to increase their output faster than the rate of population growth. Other commodities may or may not be subject to supply management but will be able to increase output as a result of market availability. The relative productivity of certain products compared to other commodities may change, resulting in a shift in production preferences. Genetic improvements which permit the replacement of existing crops with high-value crops in certain areas could alter the production patterns which have been established. The Committee considered the potential impact of such external factors on agricultural production. Table 1.12 summarizes its conclusions and is followed by a discussion of some of the pertinent factors considered by product. It is the firm belief of the Committee that these projections are modest but realistic goals for agricultural production in future in Ontario.

TABLE 1.11

Attainable agricultural productivity increases to 2000

	Annual increase in yield per hectare or per animal
Corn	1.0
Grains	0.3
Forage crops	0.0
Soybeans	0.5
White beans	0.0
Other cash crops	0.3
Animal products	0.5

SOURCE: Committee estimates

TABLE 1.12

Agricultural production projections to 2000

	Annual increase in total output			
	1981-6	1987-91	1992-6	1997-2000
Poultry	1.06	0.96	0.77	0.62
Milk & beef	1.06	0.96	0.77	0.62
Hogs	1.56	1.46	1.27	1.12
Corn	1.56	1.46	1.27	1.12
Grains	1.56	1.46	1.27	1.12
Forage crops	1.56	1.46	1.27	1.12
Soybeans	1.56	1.46	1.27	1.12
White beans	1.06	0.96	0.77	0.62
Fruit and vegetables	1.06	0.96	0.77	0.62

SOURCE: Committee estimates

Assumptions by product group

Poultry

Contributing to the increased production of poultry products will be an expected increase in productivity of 0.5 per cent annually for the period under study. The major contribution to this increase will be in the field of improved management and animal husbandry practices.

However, the overriding constraint to expansion of poultry and egg production is expected to be the marketplace. Although some forecasts indicate a major shift in consumer demand to poultry products, this factor has not been heavily weighted in this projection. Given relatively constant consumer tastes and lacking export potential, the future production of poultry and eggs is likely to follow closely the population growth rate. This will be ensured by the supply management system under which production is regulated.

Milk and beef

For these livestock groups, productivity is expected to increase at a rate of 0.5 per cent annually for the period under study. This increase will be mainly because of improved management, primarily in prevention of disease and loss. Genetic improvements through breeding and the increased proliferation of high-quality stock should also contribute to productivity gains.

The dairy industry is tightly controlled by a national supply management system. Although initiatives are being taken to increase per capita consumption, the counteraction of an aging population may result in no net gains. Therefore total output will probably grow in step with the population.

The beef industry, although still a free market system, has been subject to declining per capita consumption. Price and consumer disposable incomes will be prime factors in this trend. Strong competition in the export trade will inhibit opportunities for production expansion. Therefore total output will also probably grow at the same rate as the population.

Hogs

Increased market opportunities for hog production have been forecast. This is a reflection of the relative production costs of hogs compared to other meat products. With hog production having a higher productivity, the cost saving will probably be transmitted to the retail market and influence consumer preference. In addition, new export opportunities being explored may contribute to improved demand. This is expected to result in the growth rate in total output greater than the population.

As may be expected, the growth rates of the livestock commodities will bear a direct relation to many of the crop production requirements. Demand for cash crops and specialty crops will of course be specified by independent factors.

Corn

Grain corn production in Ontario has increased rapidly, as has its importance to farmers' as a cash crop and feed. The development of early-maturing and high-yielding hybrids is a direct result of heavy investment in research and development. The number of farmers growing corn has increased as its economic benefits and distribution in the production system have become widely realized. As farmers new to the production of corn gain experience and improve the capability of their land, overall productivity will increase. Investment in such improvements as drainage may also result in higher yields. Better scheduling of planting and harvesting and more efficient on-farm storage systems will provide high yields of marketable grain.

Expansion in the production of corn can be expected both as a result of increased demand for livestock production (particularly hogs) and a growing demand as a result of a widening product group (e.g. fructose). This expansion will be limited in its extent by its land base requirement within a minimum Corn Heat Unit area. Although productivity gains are diminishing, it is expected that, with some land base expansion, productivity gains will enable a growth rate greater than that of the population.

Grains

The production of grains in Ontario has been a longstanding practice which may no longer show increased gains as a result of improved management or technology developments. As new practices and technology are adopted, some gains in total productivity may be experienced. Genetic gains may result in increases in yield per hectare, but not as substantially as previous years (0.5 per cent a year 1971-80). An increased yield per acre of 0.3 per cent a year seems a realistic estimate for grain production.

Total output of grains is anticipated to increase at a rate greater than that of the demand created by growth in total population. Increased consumption of grains in the domestic market coupled with an expanding export market will create sufficient demand to increase production. Productivity increases will contribute to meeting this demand, but they are not expected to be the major contributors to increased output. Expansion of the land base devoted to grain production is expected to contribute the major portion of total output increases. Much of this land base expansion will occur in eastern and northern Ontario.

Forage crops

The outlook for improved productivity in forage crop production is not expected to result in total gains over the next twenty years. Although the potential for major productivity gains is widely understood, it is not expected that these techniques will be implemented. Technological and management practices to reduce the labour involved will be introduced, but not for significant productivity gains.

Market opportunities for products with forage crop inputs are expected to continue to expand. However, the lower input costs of forage production compared to other crops may result in their expanded use in various production systems. The current trend to haylage and other silage crops will contribute to expanded forage production. Total output at a rate greater than population growth may be gained by expansion of the land base and to some extent by productivity gains.

Soybeans

Improved genetic varieties of soybeans under development are expected to result in increased yield per hectare and in expanded hectarage on lower heat unit lands. Some gains can also be expected as a result of technological developments in planting, weed control, and harvesting techniques. Improved management practices are expected to spread and bring with them some total productivity gains.

Given the above, it was estimated that a productivity increase of 0.5 per cent a year could be expected in soybean production.

Increases in the total output of soybeans are expected to be greater than total population growth, spurred by increasing market and import replacement opportunities.

White beans

The proven susceptibility of white beans to airborne pollutants is unlikely to be resolved by genetic, technological, or management practices on the farm. Therefore, it is probable that productivity gains will be limited to 0.3 per cent a year for this crop in the next twenty years.

Although market opportunities for white beans are expected to increase, the limitations of land and minimal gains in productivity will restrict total output to a rate comparable to the growth of total population.

Tobacco

This specialty cash crop faces limitations of market and land base. Over the next twenty years no significant increase in total output is expected.

Fruit and vegetables

Output of these products in total is expected to increase at the same rate as that of the population. As land base requirements are specified and limited, a large portion of this increase in total output must be forthcoming from productivity gains.

AVAILABLE LAND BASE

Projected rate of decline in the area of Class 1 and 2 soil available for agricultural production, 1980-2000

The population increase of 1.6 million over the next twenty years has been discussed above. To calculate the amount of land needed to accommodate this increase in population, the following formula can be used. This formula includes not only the land required for dwellings but also that for commercial, industrial, institutional, parkland, and public open spaces.

The formula is as follows:

$y = x\ 0.856/2.223,$

where x is population and y is total developed acreage. Thus

$1\ 600\ 000 \times 0.856/2{,}223 = 616\ 104$ acres (249 000 ha).

It is assumed that 75 per cent of this development will take place on Class 1 and 2 land, so that 184,800 hectares of land will be lost to agriculture. This formula is published in ARDA Report 7 and assumes a fixed density. In recent times the denisty rate has been increasing because of higher costs of development and construction. Coupled with this is an attempt to make available a range of housing accommodation, both in size and price.

Also it is assumed that all of this increased population is going to be housed in new developments, which is not likely to happen. Downtown redevelopment and a move by some people back to the urban centres means that not all of the 249 000 hectares will be needed to accommodate the projected population increase.

Land improvements and expansion

It is difficult to project the rate at which unused Class I and 2 soils can be brought into production. To answer this question it would first be necessary to determine why those lands are not producing at present. If it is only a matter of economics they will become productive when the prices of agricultural products warrant.

Another area, and one that is equally difficult to project, is how changes in crops grown can affect overall production. These are decisions that are made by individual farmers. We have no measure of the reserve production potential or 'slack' that exists in this aspect of Ontario agriculture. In other words, what potential is there to maximize production on the present agricultural lands producing the present crops?

The CLI classification groups mineral soils which have similar limitations into classes. Where it is economically feasible for the individual farmer to correct the limitation, the soil is classified as if the improvement had been made. For example, a 2W soil requires drainage; the classification assumes that the drainage has taken place. The soil is still classified as a Class 2 soil even though there are costs in installing and maintaining the drainage system.

No inventory of the improvements feasible for the individual farmer to undertake has been made. We therefore know what lands require these improvements but not whether they have been made.

If all such improvements were in place there would undoubtedly be gains in production, but how great they would be is unknown.

Some lands can be improved by major actions which are not economically feasible for an individual farmer, such as the installation of a major drainage channel.

The Land Evaluation Model Project (Research Report 7) dealt with this aspect. The model showed that only 2.2 million hectares are required to produce our present level of production, based on the assumptions of the model. Even at the year 2000 level of population, the model still shows that the food required can be produced on 3.4 million hectares, a considerably smaller area than the 4.4 million hectares now in production.

The model assumes average conditions related to a number of factors such as weather, yields, energy inputs, production from livestock, feeding levels, and a crop rotation program. It also assumes that present levels of imports are constant. Other assumptions made are that all improvements have been made to all Class 2, 3 and 4 CLI soils, and that production will be oriented to the area with the highest potential in terms of CLI class and Corn Heat Units.

If at some future date Ontario agricultural production came to be based on these assumptions, the model would in fact now give us a measure of the 'slack' in the system.

Net land base of Classes 1 to 4, 1980-1985-2000

The Canada Land Inventory provides an overview of the acreage and location of the soils in Ontario that have the potential for agricultural use (Figure 1.10, Table 1.13).

As mentioned earlier, these lands are located along the Quebec City-Windsor axis. This area provides the land base for a large proportion of Canada's population and industrial and commercial activity; 38 per cent of Canada's population lives and works in the Ontario portion of this axis.

To put this into context, the Class 1 soils to the northwest and east of Toronto constitute half of all the Class 1 soils in Canada. If we assume that the view from the top of the CN Tower in Toronto will take in a radius of 113 kilometres, then from this vantage point one can view half of all of the Class 1 land in Ontario and one-quarter of all the Class 1 land in Canada. Because of the competition for this land from non-farm activities, there has to be real concern about its long-term availability for agricultural use.

It was pointed out earlier that certain areas of the province enjoy microclimates that provide them with a unique opportunity to produce specialty crops. The CLI classification does not identify microclimates because the classification assumptions are based only on general field crops.

Figure 1.10 Ontario soil capability for agriculture

Source: Canada Land Inventory, Environment Canada

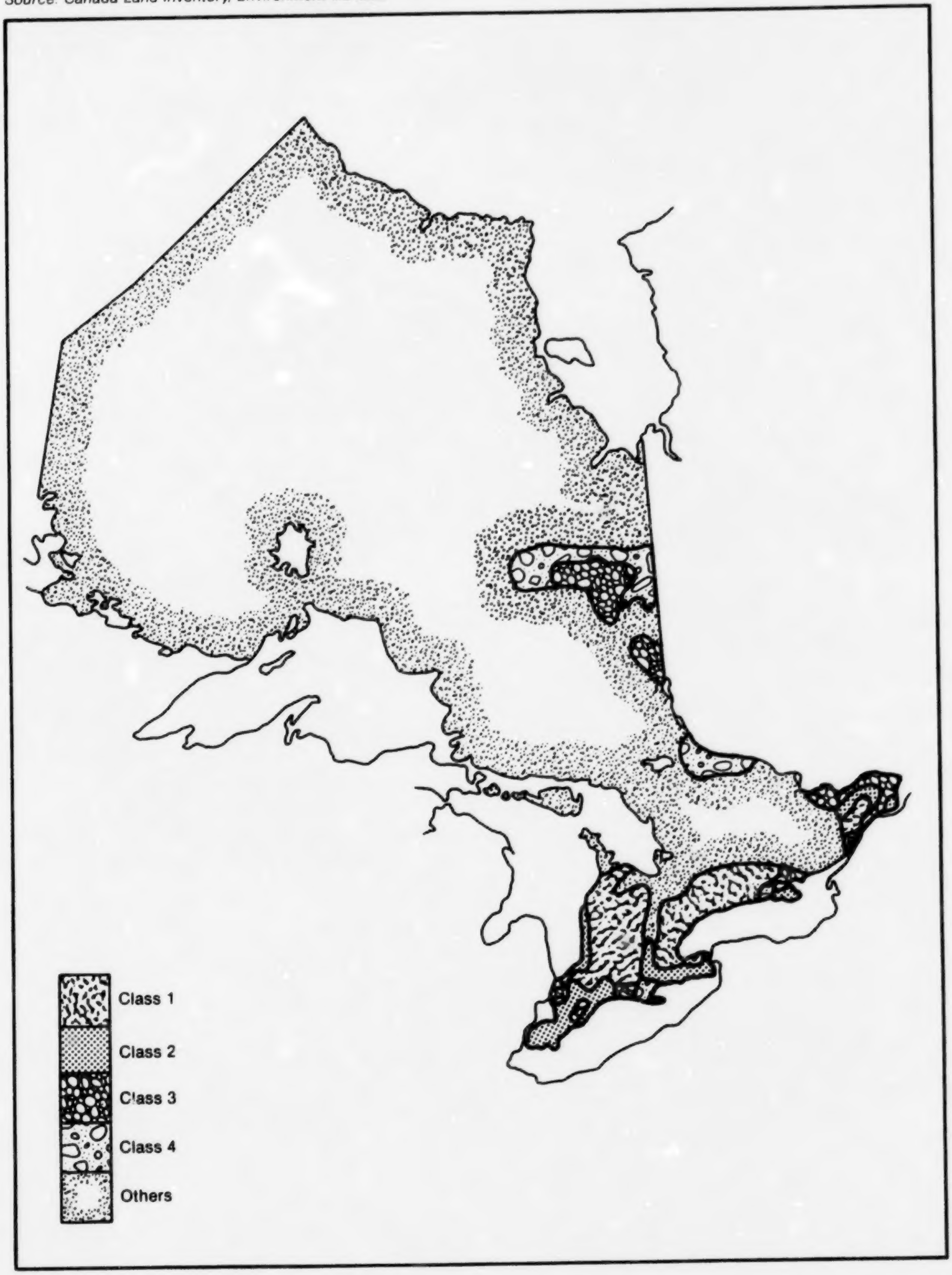

Class 1
Class 2
Class 3
Class 4
Others

TABLE 1.13

CLI soil classes by region (thousands of hectares)

Region	1	2	3	4	5	6	7	Organic	Unmapped	Total
Central	649	325	318	185	211	183	265	176	29	2341
Southern	760	1030	316	101	152	32	35	48	52	2526
Eastern	86	204	291	111	92	151	79	109	11	1134
Horseshoe	317	205	142	102	29	58	19	39	16	927
Shield	115	148	170	182	135	274	1480	177	17	2698
Northern	-	197	1258	1450	738	256	6063	1547	60	11569
TOTAL	1927	2109	2495	2131	1357	954	7941	2096	185	21195

NOTE: The total area of the province of Ontario is 90 681 088 hectares; only 23.3 per cent of the province has been classified under the CLI system. The unsurveyed land has little agricultural value.

SOURCE: Canada Land Inventory

The regions in Table 1.13 and Figure 1.10 were established on the basis of the predominant commodity or type of farm enterprise within the region. As part of the background to this Report, a study of land needs was prepared by the Land Evaluation Model (LEM 2) Project Team from the University of Guelph (Research Report 7). The LEM 2 also divided Ontario into areas defined as zones based on a combination of criteria of soils and climate. By laying the LEM 2 map over the region map, we observe that there is a general agreement between the regions and zones (Figure 1.11). Class 1 and 2 soils are concentrated in the Southern, Central, and Horseshoe Regions. The Southern and Horseshoe Regions are comparable to LEM 2 Zones 7, 6, 5, and 4. The Central and Eastern Regions compare to Zone 3, the Shield to Zone 2, and the Northern Region to Zone 1.

Figure 1.12 shows that 57 per cent of the Class 1 and 2 soils in Ontario are in the Southern and Horseshoe Regions (Zones 7, 6, 5, and 4), with another 24 per cent in the Central Region, (the western section of Zone 3). On the other hand, 58 per cent of the Class 4 soils are located in northern Ontario.

The LEM 2 Report showed that Zones 7, 6, 5, and 4 are the best lands for agricultural production. Table 1.13 and Figure 1.13 show the number of hectares of the respective soil classes by region. The area of land in actual production (farmland) is related to the CLI by region in Table 1.14 and by zone in Table 1.15.

Table 1.14 shows that a large proportion of the Class 1-4 lands in the Central, Southern, and Eastern Regions are being farmed (95, 87, and 83 per cent respectively). In the Horseshoe Region, though 82 per cent of it consists of Class 1-4 soils, the farmland area is only 65 per cent of the Class 1-4 area. Probably the other 35 per cent is not in agricultural use or is idle. In the Shield Region the farmland amounts to 105 per cent of the Class 1-4 area, suggesting total use of those soils plus some use of Class 5-6 soils for farming. In the Northern Region the farmland is only 11 per cent of the Class 1-4 area, again pointing up the reserves located in the north.

Figure 1.11 LEM Zones overlaid on regions

Source: Land Evaluation Model, Research Report 7

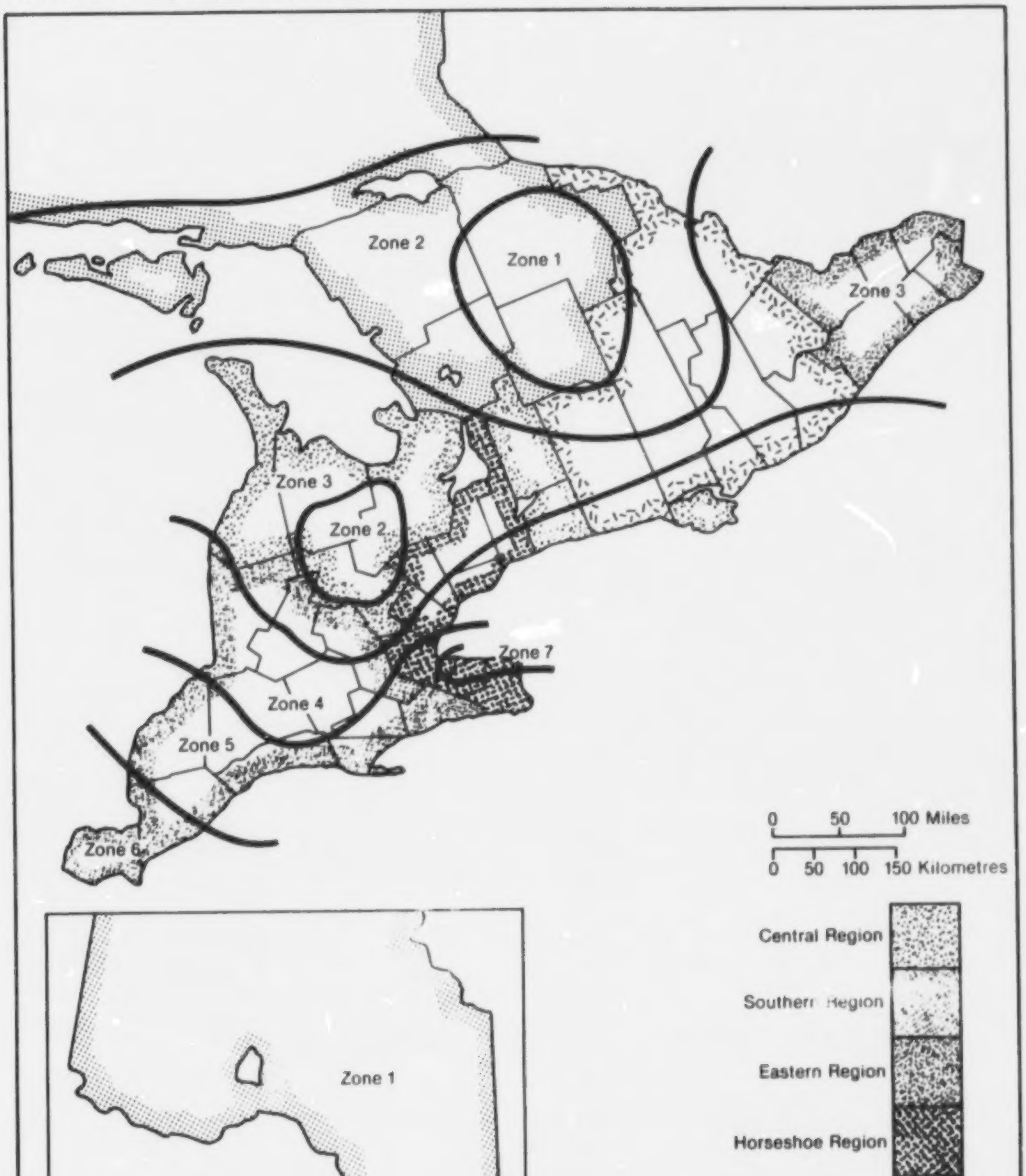

Zone 2
Zone 1
Zone 3
Zone 3
Zone 2
Zone 7
Zone 4
Zone 5
Zone 6
0 50 100 Miles
0 50 100 150 Kilometres
Zone 1
0 100 200 Miles
0 150 300 Kilometres
Central Region
Southern Region
Eastern Region
Horseshoe Region
Shield Region
Northern Region

Figure 1.12 Regional distribution of agricultural lands

Source: Based on Canada Land Inventory

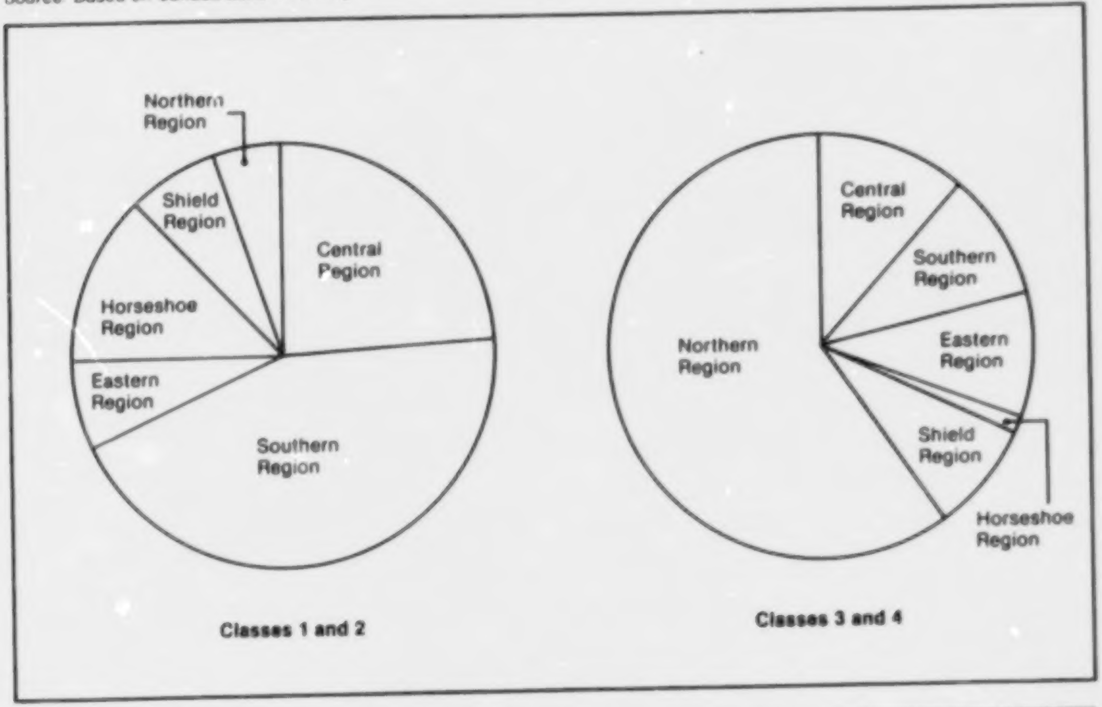


Figure 1.13 Agricultural lands by region

Source: Based on Canada Land Inventory

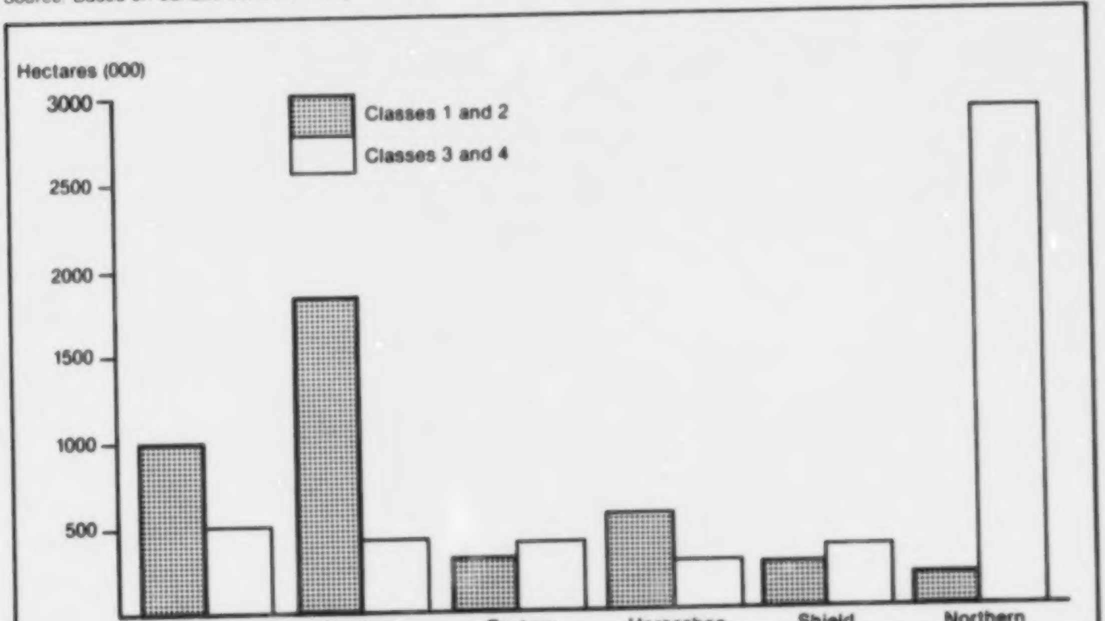


TABLE 1.14

Relationship of farmland to class 1-4 soil area by region

	CLI Class 1-4 (000 ha)	CLI/Total region area (%)	Farmland (000 ha)	Farmland/ Class 1-4 area (%)
Central	477	62	1413	96
Southern	2207	87	1931	87
Eastern	692	61	575	83
Horseshoe	766	82	499	65
Shield	615	23	651	106
Northern	2905	24	310	11

SOURCE: ARDA Report 8, Food and Development Branch Assessment Study (1980)

TABLE 1.15

Relationship of farmland to class 1-4 soil area by LEM 2 zone

	CLI Class 1-4 (000 ha)	CLI/Total zone area (%)	Farmland (000 ha)	Farmland/ Class 1-4 area (%)
Zones 7, 6, 5, 4 (Southern & Horseshoe)	2974	86	2430	82
Zone 3 (Central & Eastern)	2169	63	1988	92
Zone 2 (Shield)	615	23	651	106
Zone 1 (Northern)	2906	24	310	11

SOURCE: ARDA Report 8, Research Report 7

In the 7, 6, 5, and 4 LEM 2 zones, 86 per cent of the area of the zones is Class 1-4, and the farmland amounts to 81 per cent the Class 1-4 area (Table 1.15). In Zone 3 the Class 1-4 area is only 63 per cent of the total area, but again the farmland is a high proportion of the area in those classes. The Shield and Northern Zones exhibit the same characteristics as the corresponding regions.

It is apparent that the major reserve of farmland for the future expansion of agricultural area lies in northern Ontario.

NEW AGRICULTURAL PRODUCTS AND TECHNOLOGY

Like many other production units, the farm of today is managed as a system. A well-managed farm system will bring as many variables as possible under the control of the manager, often with such inputs as feed and fertilizer produced on the farm. This approach is not practical for all farms, but it does show what can be done. The new crops and new technology mentioned below when incorporated into the farm systems will give the farmer an opportunity to control other variables.

Field crops

Rapeseed (canola)

Rapeseed is Canada's major oilseed crop. However, very little is grown in Ontario simply because of the lack of a market. The bulk of the crop is produced in western Canada, with annual production about 3.50 million tonnes. Long-term average yields run around 1030 kg/ha. Oil content ranges from 38 to 45 per cent. The rapeseed area in Ontario may soon be on the increase because Maple Leaf Monarch, a recently established corporation jointly owned by Maple Leaf Mills and Lever Brothers, has built a new crushing plant in Windsor and has indicated that it will purchase all the rapeseed that can be produced in Ontario. Rapeseed now represents a potential alternative cash crop for Ontario farmers, particularly those in the shorter-season areas of the province (2700 heat units and less). Transportation costs may present a problem to some growers, particularly those in eastern and northern Ontario. Yields are higher in the shorter-season areas of southern Ontario than in the main soybean growing areas. Therefore, rapeseed may not be competitive with soybeans in areas where the latter have traditionally been grown. However, some growers in the longer-season areas have shown interest in rapeseed because it does not interfere, from a timing standpoint, with their full season crops.

Flax

Flax is a minor crop in Ontario, with annual production ranging from 3700 to 6100 tonnes in recent years. In Ontario the crop is grown for seed, which is crushed and processed for oil and meal.

Flax can perform better on untilled, imperfectly drained land than barley or wheat. It also fits in with other farm operations because it can be planted after spring cereals and harvested after them. Flax production in Ontario is centred in Bruce, Grey, and Dufferin and the northern parts of Huron, Perth, and Wellington Counties.

There is a ready market for flax in Ontario. Ontario production could increase substantially because 75 per cent of the flax crushed in Ontario comes from western Canada. It is unlikely that the flax area will increase in eastern and northern Ontario because of high transportation costs and lower returns per hectare than barley.

Soybeans

In 1977 Canada imported over $200 million worth of soybeans and soybean products. Since Ontario is not self-sufficient in soybeans, there is a ready market at the three major crushing plants for the Ontario-grown crop. Nevertheless, the soybean area is only beginning to expand substantially outside Essex, Kent, and Lambton Counties. In the past there has been more profit in growing corn outside the traditional soybean area. This is changing because of high soybean/corn price ratios and better early-maturing soybean varieties. In general, soybeans can now be grown anywhere in southern Ontario where corn can be successfully grown. The soybean area will probably continue to expand throughout southern Ontario because of the steady demand for soybeans and soybean products.

Sunflowers

Ontario farmers are showing interest in sunflowers as an alternative cash crop. It is estimated that about 300 hectares have been grown in Ontario in recent years, with yields averaging about 2000 kg/ha. Two types of sunflowers are grown, an oilseed type and a confectionary and wild bird feed or non-oil sunflower. The oilseed varieties contain 38 to 50 per cent oil and about 20 per cent protein. The meal left after crushing contains around 45 per cent protein. The oil is edible, has a bland taste and light colour, and has a long shelf life after refining. Ontario growers now have a marketing outlet in the new crusher at Windsor.

Peanuts

Commercial peanut farming started in Ontario in 1980 with six growers in the Delhi area harvesting a total of 76 hectares. Results have been encouraging, and it is expected that within ten years the crop may have expanded to 8000 hectares. A processing plant near Simcoe has provided the market and made commercial production feasible. The peanut grown in Ontario is the Valencia, featuring three nuts in each pod. They are mainly eaten from the shell but can also be used in peanut butter. Ontario peanuts are expected to yield about 2.20 tonnes per hectare. At an average price of 4.4 cents a kilogram, a producer could grow about $985 per hectare. Cost of production, including land costs and interest, is estimated at $865 per hectare, resulting in a net return of $120 per hectare. However, this figure should increase when Ontario-bred varieties are developed, growers become more experienced, and harvest equipment designed for Ontario conditions becomes available. Commercial peanut production probably will be confined to the better sandy and sandy loam soils in areas with 3000 or more heat units.

Sugar beets

Sugar beets have not been grown commercially in Ontario for about thirteen years. Before that time, the Canada-Dominion Sugar Company contracted with growers in the Chatham area to produce 7000 to 8000 hectares a year. Average yields ran around 35 tonnes per hectare with a high of 44 tonnes per hectare in 1965. Although experience with sugar beets is confined to southwestern Ontario, it expected that this crop could be grown successfully in all parts of the province. In general, sugar beets grow best on well-drained clay loam soils, although some growers on sandy loam soils have obtained fairly good yields. Processing plants would have to be available near the crop to make commercial production feasible.

There has been interest lately in fodder beets for ethanol production. This variety consists of a cross of sugar beets with mangolds. It combines the high yields and varied growth habit of mangolds with the high dry matter content of sugar beets. Sugar yields of 64 to 70 per cent of root dry matter with root yields of up to 20 oven-dried tonnes per hectare have been recorded in dry land production and up to 30 oven-dried tonnes per hectare under irrigation in New Zealand. This irrigated yield is reputed to produce over 9000 litres of ethanol per hectare, compared to 4000 from sugar cane and sugar beets, 2300 from cassava and eucalyptus, and 1000 litres from wheat.

Ongoing plant breeding and variety-testing programs

Intensive plant breeding and variety-testing programs are being conducted by Agriculture Canada, the Ontario Ministry of Agriculture and Food, the University of Guelph, and several privately owned seed companies. This continuing effort has contributed greatly to soil and crop improvement over the years. Examples are the soil-testing program, which recommends optimal rates of fertilizer for all crops grown in Ontario, the tremendous increase in the hectarage and yield of corn since the 1950s, the introduction of birds-foot trefoil as a pasture legume for imperfectly drained soils, the greatly improved early-maturing soybean varieties that have enabled farmers to grow soybeans through most parts of southern Ontario, and the research on the peanut crop.

New agricultural crops or products

It is not likely that many new crops will be introduced into Ontario in the next twenty years. However, new varieties of crops will continue to be bred and adapted to new areas of the province. Drainage of wet soils combined with new markets for these products will provide economic incentives for this growth.

Horticultural crops

Horticultural crop production has a moderate to excellent opportunity to increase in future in view of the per capita consumption of fruits and vegetables, the projected population growth, and the replacement of imports. The high cost of transportation and the current value of the Canadian dollar make import replacement even more feasible.

Fruit crops with a growth potential exceeding that of population growth are apples, peaches, pears, grapes, and strawberries for the fresh market; cranberries may have a limited growth potential.

Fresh market sales of apples could be increased with the development of a green apple variety to compete with the Granny Smith imports and the improvement of storage facilities and techniques to extend the marketing season. Opportunities exist to increase production of apple juice and apple concentrate, but before orchards are planted strictly for this market extreme caution must be exercised to ensure that the other segments of the apple industry are not disrupted by such plantings.

More clingstone peaches should be produced to replace imported canned products, but lack of suitable land in favourable climatic zones restricts any significant increase.

Grape production is also increasing and will continue to do so not only to satisfy the commercial wine and juice market but also to replace grapes imported for home winemaking and for the fresh market.

The production of strawberries for processing presents one of the greatest opportunities for production expansion mainly because of the development of new varieties, mechanical harvesting equipment, and automatic hulling machinery. This would be an import replacement program.

Highbush blueberry production has recently gained popularity mainly for pick-your-own and roadside markets. Efforts are also being made to bring the wild, lowbush blueberry under cultivation in eastern and northern Ontario. Cranberries are not at present grown commercially in Ontario, but recent research has shown that more production is possible, with the major obstacle being the high capital cost of establishing a planting.

Asparagus, sweet corn, cole crops, mushrooms, and processing tomatoes are the vegetable crops with the greatest growth potential, while carrots, cucumbers, onions, potatoes, green house cucumbers, and greenhouse tomatoes have limited growth potential.

A recent study identified the need to establish an additional 1330 hectares of asparagus to replace imports. This is more than double the present production. Exports of frozen whole kernel corn and frozen or canned corn-on-the-cob make sweet corn a vegetable crop in which production far exceeds domestic requirements. Opportunities to increase exports of processed sweet corn appear excellent.

Increases in the production of cole crops such as cabbage, broccoli, brussels sprouts, and cauliflower have been occurring and should continue, mainly to replace imports. Cabbage varieties that maintain their green colour in storage, coupled with improved storage techniques, are extending the market season for fresh cabbage in Ontario. Domestic demand for cabbage as cole slaw is also increasing because of demands from fast-food outlets.

Per-capita consumption of mushrooms has increased dramatically in recent years mainly because of the popularity of pizza parlours and other fast-food outlets. This factor, plus efforts to replace part of the canned mushroom imports, create the opportunity to increase mushroom production even further.

Recent reports indicate that an additional 1750 hectares of tomatoes could be grown in Ontario to replace a portion of Canada's imports of tomato solids products. This would represent a 15-20 per cent increase in tomato production in Ontario.

Production of seed potatoes can be increased in Ontario, but any increases in production of table stock or processing potatoes are subject to heavy pressure from potatoes brought in from other provinces.

Considering the increase in per-capita consumption, projected population growth, and the reclaiming of a portion of the domestic market currently lost to imports, a modest increase in production of greenhouse vegetables should be achieved in the future. A strong market promotion scheme could make the increased production even more significant. Reduction in production costs by using waste heat and energy conservation techniques would make import replacement even more feasible. Studies are also under way to determine the economics and feasibility of growing alternative crops in greenhouses, e.g. lettuce, eggplants, and melons.

The production of ornamental crops including greenhouse flowers, bedding plants, and nursery stock is not directly related to the general economy of the country. In fact, it appears that as the economy gets tighter, people spend more money to beautify their homes and properties since more time is being spent there.

The production of most horticultural crops has a much higher labour requirement than that of field crops, and efforts are continually being made to reduce the high cost of labour through mechanization. Examples of this are the mechanical harvesting of tomatoes and cucumbers, direct seeding of tomatoes, and mechanical handling of cole crops. This change will mean the replacement of human energy with other types of energy.

Pest management programs being initiated to control insects and diseases on fruit and vegetable crops will result in more efficient control methods and should also reduce the number of applications. Any reduction in the number of sprays will directly reduce fuel consumption and indirectly reduce the energy required to produce pesticides.

New aquacultural products and technology

Ontario has at present sixty-six licensed fish farms. Most of them are privately operated, and three or four fishing clubs produce trout for sale in addition to the fish required for recreational fishing.

Under regulations by the Ontario Ministry of Natural Resources, fish farmers are permitted to produce bass and trout upon acquisition of a hatchery license. In practice the only type of fish produced on a commercial scale is rainbow trout. Bass, mainly for stocking of private ponds, are produced on a very limited scale.

Fish farmers are prevented from expanding the variety of fish they can produce on a commercial scale by the regulations of the Ministry of Natural Resources.

In addition to food-size or table-size rainbow trout (27-30 cm), many trout farmers raise fry or fingerling trout for pond stocking or for sale to other trout farmers, and a few specialize in producing fish eggs.

The 1980 production of table-size rainbow trout in Ontario is estimated at 527,000 kg, valued at $2.75 million. Six major producers account for about 58 per cent of this total.

Given the availability of Ontario's water resources, the industry, subject to proper development, not only could supply the large market of Ontario, estimated at 2.7-4.5 million kg of trout a year, but could also become a net exporter of trout. At the moment about 56 per cent of rainbow trout consumed in Ontario are imported from outside Canada, and imports are on the increase, an indication that per-capita consumption of trout is increasing more rapidly than domestic production of this commodity. Fish in general, and trout in particular, have high feed conversion efficiencies. On average, 1 kg of trout is produced from 2 kg of feed. However, trout are carnivorous fish and require high-protein feed, usually containing animal proteins. The optimum water temperature for trout production is about 14°C. With the possible utilization of heated cooling waters from thermal and nuclear power plants, trout could be produced in a much shorter period of time than currently required (usually more than a year). A genetic change in the species, for instance by cross-breeding with arctic char, could also result in a strain of fish relatively resistant to cold water.

Future fish-breeding programs that would use available water resources should aim at herbivores, because these fish convert vegetable feeds to an edible food more efficiently than our present meat-producing livestock.

CHAPTER 2

ENERGY IN ONTARIO

CONSUMPTION, PRICES, AND SUPPLY: HISTORIC AND CURRENT

In discussing energy consumption in Ontario it is important at the start to make clear the distinction between primary and secondary energy. 'Primary energy' denotes the energy content of the raw materials from which consumer forms of energy are made. 'Secondary energy' is that which is consumed by end users. Thus crude oil is a form of primary energy, while the consumer products made from crude oil, such as gasoline, diesel fuel, and heating oil, are forms of secondary energy.

Electricity also is a form of secondary energy. In Ontario it is generated mainly from water-power, coal, and uranium and to a very small extent from oil and natural gas. This distinction enables us to complete the picture of Ontario's primary energy sources. Crude oil meets about 40 per cent of Ontario's primary energy needs. Natural gas meets 21 per cent, coal 14 per cent, water-power 13 per cent, and uranium 10 per cent.

The forest products industry burns its mill residues to supply part of its own energy needs. This use of solid wood waste and spent pulping liquor amounts to about 1.5 per cent of total Ontario consumption. Some wood is also burned for domestic heating, but the total amount is small at present.

In examining consumption of energy by sector, it is more convenient to speak of secondary energy. In Table 2.1 we see that for the year ended September 1979 the industrial sector accounted for 46 per cent of the secondary energy consumed in Ontario. Agriculture, with only 3 per cent of total energy consumption, is clearly a light energy user in comparison not only with industry but also with the commercial, residential, and transportation sectors.

TABLE 2.1

Secondary energy use in Ontario by sector share, 1979

Sector	Share
Industrial	45
Transportation	23
Residential	17
Commercial	12
Agriculture	3
	100

NOTE: For twelve months ending September 1979. Agricultural energy is fuel and electricity only; fertilizer use is not included.

SOURCE: Ministry of Energy

Consumption by fuel type and category

Oil

Recent trends in the consumption of oil products in Ontario are presented in Figure 2.1, which shows the end use of energy products in the residential, commercial, industrial, and transportation markets. About half of Ontario's oil consumption occurs in transportation. Residential, or household, uses consume 13 per cent; industrial uses, including mining and manufacturing, consume 10 per cent. The commercial sector (for example, institutions, office buildings, schools, street lighting, and water works) uses only 5 per cent of the province's oil. The remainder is accounted for by consumption of petrochemical feedstocks, asphalt, lubricating oils, and other non-energy products, as well as oil use by the refineries themselves.

Following the price increases begun by OPEC in 1973 the consumption of oil products fell off in 1975, but it has since increased. Much of the increase is accounted for by greater use of petrochemical feedstocks and refinery fuel. Since 1970, consumption for transportation has been growing steadily, while the combined requirements of the industrial, commercial, and residential sectors have declined.

The oil consumed in the agricultural sector is primarily in the form of gasoline and diesel fuel, amounting to 3 per cent of the gasoline and 6 per cent of the diesel fuel consumed in Ontario. Gasoline accounts for 63 per cent of the petroleum-based fuels consumed in agriculture, with diesel accounting for 34 per cent and heavy fuel oil for the remaining 3 per cent (light fuel oil and kerosene consumed on farms is all classified as 'residential' by Statistics Canada).

Natural gas

Ontario uses three times as much natural gas now as it did in 1965. As Figure 2.2 shows, the province's gas consumption grew rapidly from 6.2 billion cubic metres in that year to 18.4 billion cubic metres in 1974. It then grew slightly until 1979, when its price advantage and public concern over oil supplies resulted in a renewal of domestic conversions to natural gas. In 1979 natural gas consumption was 19.4 billion cubic metres.

Figure 2.1 Oil consumption in Ontario

*Includes petrochemicals, lubricating oils, waxes, asphalt, etc
**Includes agricultural use, which accounts for less than 2 per cent of the total

Source: Ontario Energy Review

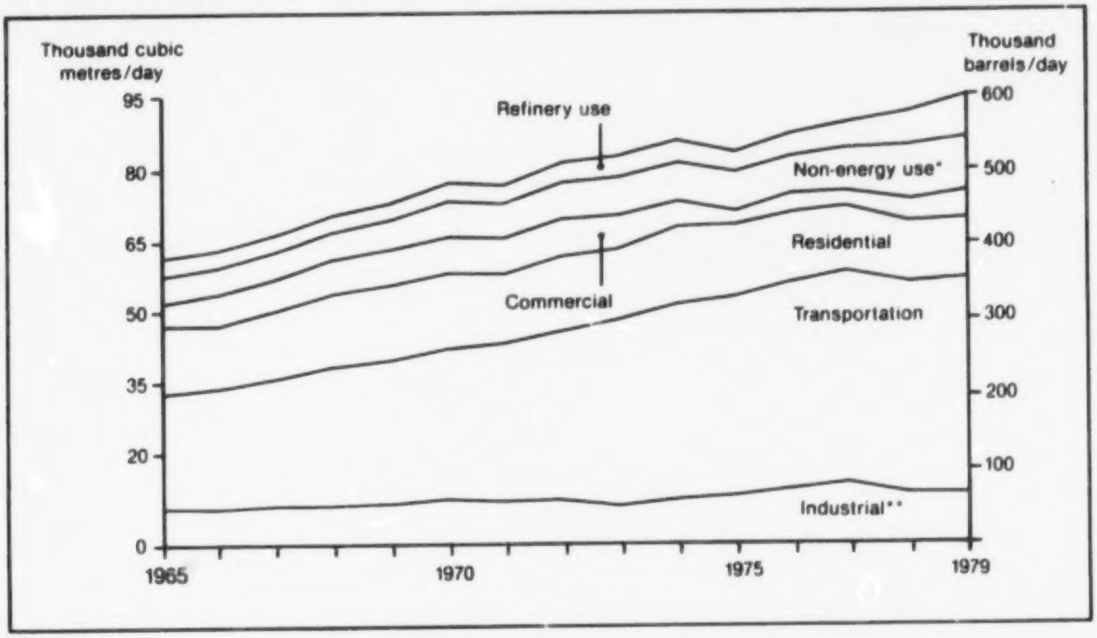
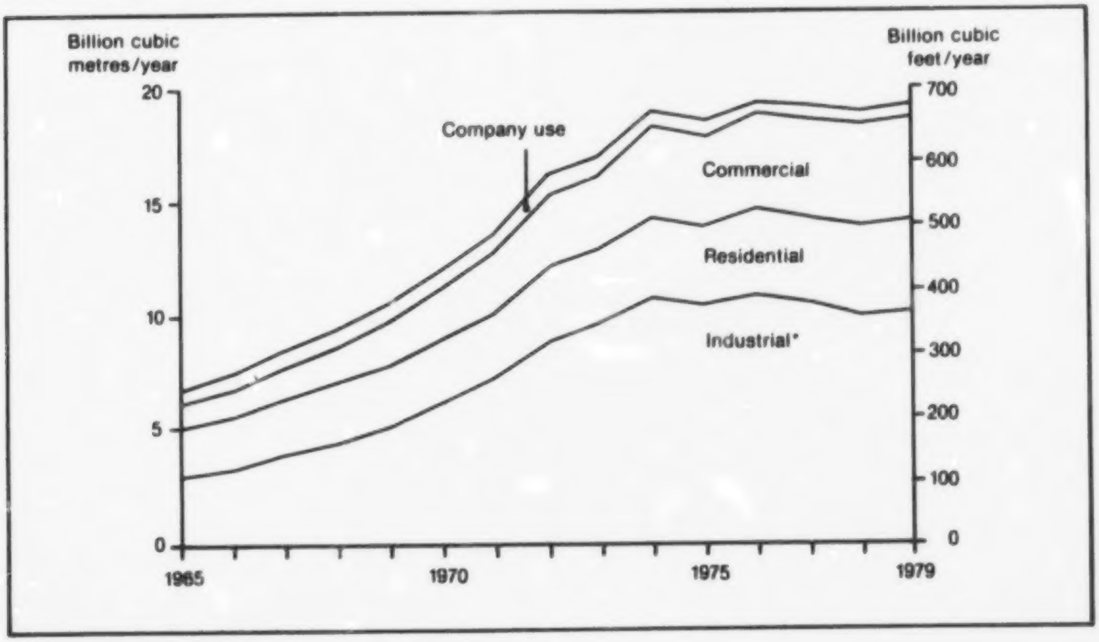


Figure 2.2 Natural gas consumption in Ontario

*Includes sales of natural gas for electricity generation. Also includes agricultural use, which amounts to less than 1 per cent of provincial consumption

Source: Ontario Energy Review



Industrial uses (54 per cent at present) predominate, their share having risen from 48 per cent in 1965. The industrial sector includes the natural gas used to generate electricity, which has declined quite rapidly in the last few years. The commercial sector's share now stands at 23 per cent, while the residential sector accounts for 20 per cent. In both the residential and commercial sectors, average per-customer use has been declining, mainly as a result of conservation efforts. On the other hand the number of new residential customers that have converted from heating oil to natural gas has been most significant. About 8000 homes converted to natural gas in 1978; in 1979 conversions had risen to 24,000 homes; and in 1980 it is estimated that 40,000 to 45,000 conversions took place.

The limited use of natural gas directly as fuel in agriculture is reflected in the fact that such use accounts for less than 1 per cent of Ontario's total consumption.

Propane

Propane is a petroleum gas that can be liquefied at relatively low pressure at normal atmospheric temperatures. Thus it can be conveniently stored and transported as a liquid in light pressure tanks. When the pressure is reduced the liquid boils, releasing a clean-burning gaseous fuel. Propane can be used in a great variety of applications, including gasoline blending, heating, cooling, and crop-drying. Attention has recently been focused on the use of propane as a transportation fuel to replace gasoline.

Propane is already widely available and used in a variety of heating applications in Ontario. Small amounts are used for transportation. In 1979 Ontario used about one million cubic metres of propane for energy and as a petrochemical feedstock. There are already more than fifty bulk propane distribution terminals in Ontario and several hundred retail outlets.

Propane distributing companies plan to establish at least one hundred vehicle fuelling stations to serve local fleets, and the number of propane vehicles on the road is expected to grow to at least 40 000 by 1985.

To stimulate the increased use of propane for transportation, the Ontario government removed the sales tax from licensed vehicles powered exclusively by propane and exempted it from the Ontario gasoline retail taxes.

Coal

Almost all coal consumed in Ontario is used either in steel-making or in generating electricity. Apart from these applications the residential, commercial, industrial (apart from steel manufacturing), and transportation sectors combined consume only about 3 per cent of the coal used in the province, down markedly from their 39 per cent share in 1965.

Metallurgical coal consumption has increased, and its share of total consumption has risen from 32 per cent (4.3 million tonnes) to 41 per cent (7.2 million tonnes) today. However, for a variety of reasons such as declining automobile production and the current recession, Ontario's steel-makers continue to experience slower growth in product demand, which is reflected in a lower growth rate in their coal requirements.

The use of coal in generating electricity has doubled since 1965, increasing its share of total consumption from 29 per cent to about 56 per cent in 1979.

Electricity

Since 1965 the pattern of electricity consumption has hardly changed; consumption in all sectors has simply doubled. Commercial and industrial users still consume about two-thirds, while residential and farm uses remain just over one-quarter. The agricultural sector consumes approximately 2.5 per cent.

Historically, the demand for electricity in Ontario has grown at about 7 per cent annually. Since 1974 the growth in demand has declined to 3.9 per cent. Ontario Hydro's 1980 load forecast, released in February 1980, predicted an average growth in the demand of 3.4 per cent annually to the end of the century.

Energy prices - historic and current

The wholesale price of energy in Ontario has increased sharply since 1973. For some fuels the 1980 prices were four times the 1973 levels. Retail prices, however, have increased less dramatically, since processing and distribution costs and (in the case of gasoline) taxes have not risen as sharply.

The recent movement of retail prices in Ontario is shown in Figure 2.3 in which the Toronto consumer price index (CPI) is compared with price indexes for residential heating oil, natural gas, electricity, and gasoline and with the index of personal disposable incomes since 1965. Through the 1960s, energy prices lagged behind the CPI — natural gas prices in fact did not change at all until 1973. It was in 1973 also that the heating oil index clearly passed the CPI.

Since 1973 all four energy price indexes have risen more than the CPI. Instead of holding back the over-all price increase, energy is now driving it upwards.

A similar pattern emerges when growth in income is compared with the increases in energy prices. In particular, home heating oil and natural gas prices have increased more rapidly than incomes since 1973, so that unless homeowners have taken measures to reduce their consumption, they will be devoting a larger share of their household budget to paying for energy.

Figure 2.3 shows only proportional increases, not the prices themselves.

Energy supply — historic and current

Oil

Canada. The country is not self-sufficient in oil. In 1979 Canada produced 256 000 m^3/day of crude oil and equivalent and consumed about 300 000 m^3/day. Canadian production includes synthetic crude oil from oil sands, which averaged 15 000 m^3/day during the year. Canada imported about 97 100 m^3/day of crude oil but also exported about 45 900 m^3/day to the United States, so that net imports were 51 200 m^3/day, about 17 per cent of the country's requirements.

The National Energy Board estimated Canada's established remaining recoverable reserves of conventional crude oil as of 31 December 1978 at 866.5 million cubic metres. Besides proven conventional oil reserves, it is estimated that 4.2 billion cubic metres of synthetic crude oil can be recovered from the oil sands by surface mining (improved mining methods could increase this figure to more than 12.7 billion cubic metres) and a further 31.8 billion cubic metres by 'in-situ' methods. Canada also has significant oil resources in the frontier areas - the Arctic, the Mackenzie Delta, the Beaufort Sea, and off the east coast. Exploration off Newfoundland led to the discovery of the Hibernia oil field in August 1979.

Production from established conventional oil reserves in western Canada will decline substantially over the next decade. It is true that new discoveries of western conventional oil are expected and that new techniques to extract a larger proportion of the oil in the ground will make a growing contribution to supply. But together these two sources of additional supply are unlikely to be enough to compensate for the decline in conventional oil production. Significant volumes of crude oil production could be attained from frontier sources by the mid-1990s, but it would be premature to count on those supplies at this time. During the late 1980s and early 1990s an increasing contribution to Canadian supply will be required from the oil sands.

In 1981 the National Energy Board completed an inquiry into the future supply of and requirements for energy in Canada. Figure 2.4 shows the range of forecasts of supply and demand for Canadian oil presented to the Board as part of this inquiry. These forecasts show that Canada has the potential to be self-sufficient in crude oil.

The Ontario government has advocated a national target of achieving crude oil self-sufficiency for Canada by 1990, and that target has been endorsed by the government of Canada. Achieving crude oil self-sufficiency will require significant investment, because oil sands and frontier sources are relatively expensive. Further technological development is also necessary; for example, the technology for the recovery of in-situ reserves is not yet proven. Although large investments will be required, there is an urgent need to proceed with new oil sands development.

Ontario. The province accounts for 33 per cent of total Canadian oil consumption. Yet only a tiny amount (less than one-half of 1 per cent of Ontario's consumption) is provided from Ontario's own production, which in 1979 was 253 m^3/day. About 91 per cent of Ontario's crude oil supply comes from western Canada through the Interprovincial Pipeline. Most of the rest is supplied from American crude oil exchanged for equal quantities of western Canadian crude oil delivered to refineries in the United States. No imports of crude oil from outside North America were received in Ontario in the past year, although parts of eastern Ontario were supplied with refined petroleum products produced in part from foreign crude oil refined in Quebec. Ontario has no direct access to large volumes of offshore crude oil supplies. The pipeline from Sarnia to Montreal requires further investment to make possible a reversal of the flow of crude oil, and the harbour facilities at Portland, Maine, and the pipeline from Portland to Montreal would require expansion to accommodate any significant additional volumes of crude oil destined for Ontario.

Figure 2.3 CPI and energy indexes

Source: *Ontario Energy Review*

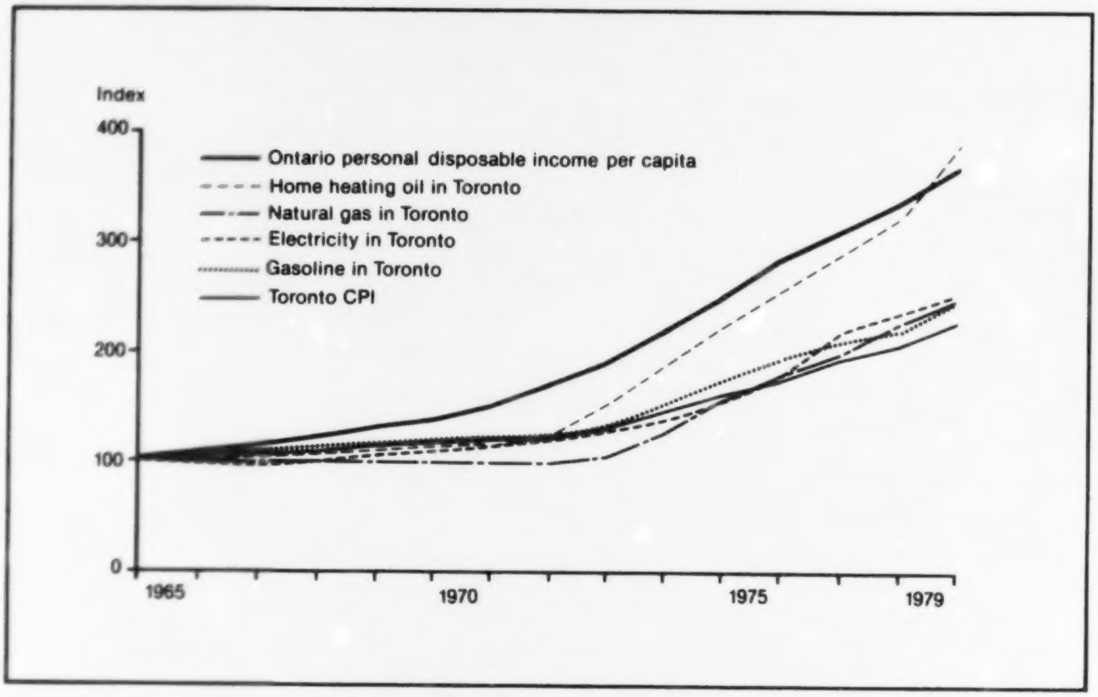
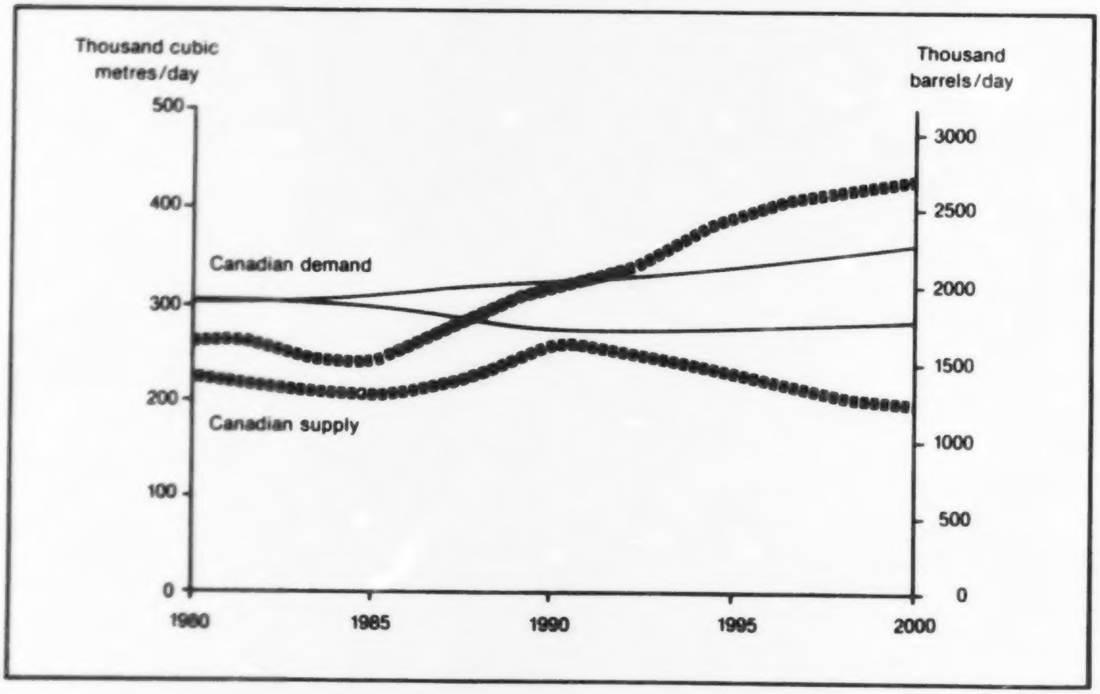


Figure 2.4 Canadian oil supply and demand outlook

Source: *Ontario Energy Review*



Natural gas

Canada. World natural gas production as a source of supply for Ontario is of no immediate importance because Canadian gas supplies are adequate to the country's needs. Most natural gas reserves in Canada are in Alberta, with smaller but significant quantities situated in British Columbia and Saskatchewan.

Significant reserves have been found in the Arctic Islands and in the Mackenzie Delta/Beaufort Sea area, and there are prospects off the east cost of Canada. However, these reserves cannot be counted on unless enough additional quantities are found to make their development and movement to market worthwhile.

The National Energy Board's latest estimates of the ultimate potential of marketable natural gas in the conventional producing areas of Canada are as follows: British Columbia 595 billion cubic metres, Alberta 4.2 trillion cubic metres, Saskatchewan 85 billion cubic metres, and the other provinces 28 billion cubic metres. About two-thirds of this total has been found to date, and nearly one-quarter has been produced.

Ontario. Most of Ontario's natural gas is supplied from western Canada, mainly Alberta. Ontario's domestic production of gas accounts for only about 1.5 per cent of Ontario's supply. Imports of natural gas from the United States, which reached a peak of about 23 per cent of total supply in 1968, have been phased out.

Western Canadian gas is delivered by TransCanada PipeLines Ltd over two pipeline systems, one of which runs through northern Ontario and the other south of the Great Lakes.

Some of the gas is piped to underground storage pools in southwestern Ontario. With new pools added in 1978 the province's total storage capacity has now reached 3.9 billion cubic metres, about two months' supply. This storage capability not only provides security of supply in emergencies but also allows distributors to purchase gas at a constant flow, meet winter peak demands, and minimize transportation cost.

Propane

Propane and associated butane are produced in Canada from gas plants and oil refineries. Gas plants, which extract propane and butane from natural gas, accounted for more than three-quarters of the total Canadian production of about 35,000 m^3/day in 1979. Oil refineries accounted for the rest. About 62 per cent of Canadian production was exported; industrial uses accounted for about 26 per cent and residential uses for the remaining 12 per cent.

Coal

Ontario produces no coal but depends on the Appalachian region of the United States, western Canada, and the Maritimes for supplies. In 1979 about 87 per cent of the coal consumed in Ontario came from the United States; the remaining 13 per cent came from Canadian sources, primarily in western Canada.

Canadian coal has always fulfilled only a small part of Ontario's coal needs. That is because transportation costs make western Canadian coal shipped to Ontario 40 to 50 per cent more expensive than Appalachian coal on a heat-content basis. The production facilities for Nova Scotian coal, the quality of which is similar to that of American coal, are limited. Ontario Hydro is expanding its use of western Canadian coal to diversify its supply sources and to obtain low-sulphur grades that can be blended with American coal.

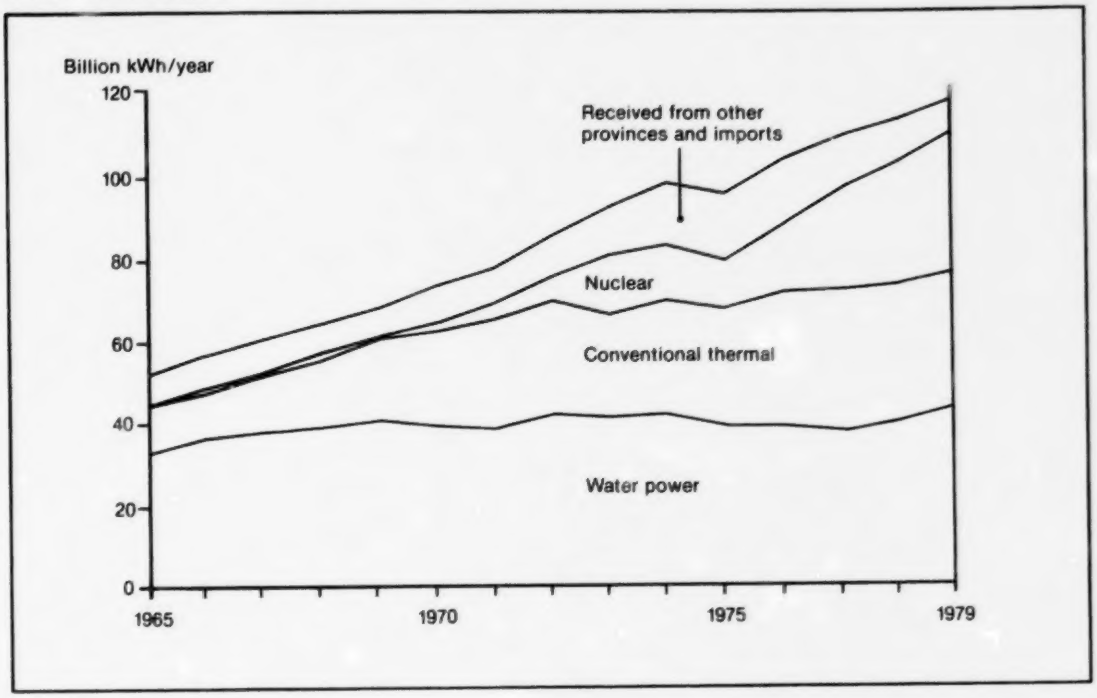
The other significant use for coal in Ontario is to make coke for manufacturing steel. The three largest steel companies in Ontario and Canada - Algoma, Dofasco, and Stelco - import almost all their coking coal from the United States.

Electricity

Electricity is a secondary source of energy manufactured from coal, water-power, uranium, oil, and natural gas. Figure 2.5 shows that the primary energy composition of Ontario electricity has changed dramatically over the last decade and a half. Since 1965 Ontario's electrical energy supply has more than doubled. In that time, however, the output of Ontario's

Figure 2.5 Electricity supply in Ontario

Source: Ontario Energy Review



traditionally predominant source of electricity, water-power (hence 'hydraulic' or 'hydro' electricity), has remained relatively constant, so that the rivers and dams that provided 63 per cent of Ontario's electrical power in 1965 now account for only 36 per cent of the total. Ontario Hydro recently announced almost complete phasing out of natural gas for the generation of electricity.

In 1965 less than one-quarter of Ontario's electricity was thermally generated, using coal, oil, or natural gas. By 1979 conventional thermal output had tripled so that coal (with small amounts from oil and natural gas) produced about 29 per cent of the province's electrical supply.

In the 1970s the most important development was the onset of nuclear-powered (uranium) thermal generation. Uranium-based electricity has expanded rapidly in the last several years until in 1979 about 29 per cent of the province's electrical supply was produced by that means.

The final component of Ontario's electrical supply consists of purchases from Quebec, Manitoba, and the United States. In absolute terms these imports have remained generally constant since 1965, but in relative terms they have declined from 10 to 7 per cent. Purchases continue for reason of economy despite Ontario Hydro's surplus generating capacity of between 2000 and 3000MW. Occasionally a neighbouring electrical utility can produce more power from an efficient generating station than its system requires. If at the same time a temporary increase in demand occurs in Ontario, it may be cheaper for Ontario Hydro to purchase that electricity than to start up additional higher-cost generating capacity.

THE ENERGY OUTLOOK

Demand projections

The Ministry of Energy's demand forecast model supplies forecasts of energy demand in Ontario for the period 1980-2000 by sector and by fuel.

The major assumptions made by the following forecast, prepared early in 1980, are as follows:

- there will be no major technological breakthroughs affecting energy use;
- only policy measures that are now implemented, or widely accepted as sure to be implemented, are considered;
- no major social or political upheaval will radically change the structure and pattern of energy use;
- the marketplace will continue to determine resource allocations;
- consumers will actively pursue energy conservation opportunities;
- the Ontario economy and population will develop along the lines forecast by the Ministry of Treasury and Economics.

The forecast presented here takes into account neither the measures included in the National Energy Program nor those in the ten-point Oil Substitution and Energy Conservation Program announced by the Ontario government on 10 October 1980. In introducing this new program the Ontario government updated and tightened its energy policy targets for energy conservation and the substitution of alternative fuels for those based on crude oil (these targets are outlined below).

If the targets are reached, the growth in secondary energy consumption in the province from 1980 to 1995 will average 1 per cent annually rather than the 1.5 per cent shown in the forecast. Annual oil consumption by 1995 would be 3.7 million cubic metres less than in 1980. Ontario would be purchasing from outside the province less than 63 per cent of its primary energy needs and would be supplying at least 5 per cent of its needs from renewable and recoverable resources such as municipal wastes, forest wastes, industrial waste heat, agricultural crops and residues, poplar plantations, synthetic liquid fuels from biomass, and solar energy.

Detailed demand forecasts

The future growth rate of secondary energy consumption by the year 2000 is expected to be lower than in the past and to average only 1.5 per cent from 1980 to 2000.

According to the model, energy consumption in the industrial sector will grow faster than in the other three sectors. The industrial sector's share of the total will expand from less than 40 per cent in 1965 and 1975 to one-half in 2000. Transportation's share will remain the same over the period at about one-quarter. The residential and commercial sectors' shares meanwhile will decline steadily, from 22 and 14 per cent respectively in 1975 to 15 and 10 per cent in 2000. The four sectors will therefore maintain their current rank in terms of the amount of energy used: industrial first, then transportation, residential, and finally commercial.

Between 1965 and 1975, gas and electricity's shares of the total market increased, and the shares of oil and coal dropped. Over the forecast period the shares of secondary energy demand for electricity and coal are projected to increase, and that of oil to decrease further. Natural gas's share will decline somewhat in the 1990s, primarily because of a projected larger share for coal in the industrial sector and the greater competitiveness of electricity in the residential sector. By the end of the century nearly three-quarters of secondary consumption of oil will be for transportation.

While the Ministry's model does not provide a separate forecast for propane, one of the assumptions for the transportation sector is that propane-powered vehicles will number 40 000 by 1985 and 100 000 by 2000. This level of penetration is not large enough to require any major expansion of the existing propane supply network or to raise its price significantly.

Supply projections

The energy demand projections above are based on various supply assumptions. Uncertainties in the supply outlook thus become uncertainties in the consumption forecast. Canada and therefore Ontario face two chief supply risks: international crude oil supply disruptions by major producing countries and a failure to proceed with Canadian oil sands, heavy oil, and frontier development in a timely fashion. Barring these two occurrences, the consumption projections presented earlier provide a reasonable picture of the range of alternatives likely to prevail in Ontario.

The following is a brief summary of where Ontario's energy supply is likely to come from.

Oil

Production from established conventional oil reserves in western Canada will decrease greatly over the next ten years. New discoveries of western conventional oil are expected but will probably not offset the drop in conventional production. Tertiary recovery and other new methods of oil extraction will make a growing contribution, but they will not completely meet the shortfall either. Major oil sands plants operating now provide about 24 000 m^3/day of premium-quality oil. Other plants are planned but are not expected to be made operational rapidly enough to satisfy the gap between projected demand and domestic supply until the 1990s.

There is encouraging evidence of major deposits in frontier areas and off the east coast, but the short-term contribution is likely to be small. The federal National Energy Program warns against counting on frontier resources to solve the oil supply problem.

The only sure way to guard against oil supply interruption is for Canada to become self-sufficient in oil. According to the National Energy Program, oil importation into Canada could reach zero by 1990. Whether this objective will be achieved is still in doubt. But the mechanisms proposed are to reduce the consumption of oil, primarily through conservation and the substitution of more plentiful fuels, and to increase domestic supply. However, it may take some time to moderate oil demand, whereas Canada's conventional oil supply is expected to dwindle rapidly. Imports of oil may consequently increase for the next few years before beginning to decline.

Natural gas

Alberta provides 99 per cent of Ontario's natural gas. Recent National Energy Board projections suggest that conventional producing areas in western Canada will be capable of satisfying both domestic requirements and existing export commitments beyond 1990.

Eventually the conventional gas supply from Alberta is expected to be replaced by supplies from frontier areas, some of which promise significant new gas sources. However, because of the lead times required to replace the cheaper conventional natural gas supplies, it is possible that some temporary market shortages could occur. Apart from these possible short-term difficulties, Canadians should have sufficient natural gas available for the foreseeable future.

Propane

With its secure supplies of natural gas, Canada is unlikely to suffer any shortages of propane during the next twenty years.

Coal

Although the present high transportation cost of moving coal from Western Canada to Ontario could limit access to the largest coal reserves, coal nevertheless represents a fairly secure long-term energy source in Canada, and future technological development could have a very significant effect on its rate of development.

Electricity

The long-term growth in electrical energy use is expected to be slower than in the past, though its share of the energy market will increase. Ontario Hydro's committed generation-expansion program and other projects under consideration, including medium-scale hydroelectrical schemes, development of the lignite coal resource in northern Ontario, joint-venture industrial cogeneration schemes, and new coal and nuclear units, together ensure that Ontario consumers will probably not experience electricity shortages in the foreseeable future.

Energy price projections

Overview

The Ministry of Energy has supplied forecasts for the years 1985 and 2000 for petroleum fuels, natural gas, propane, and electricity. By 1985 electricity will have become more competitive with both oil and natural gas. While electricity's price is expected to rise by between 60 and 70 per cent, both oil (light and heavy) and gas are forecast to rise by 100 to 130 per cent. The increase in the propane price is expected to be about 70 to 80 per cent.

By 2000, electricity will have become even cheaper in relation to its competitors, while natural gas prices will have risen more rapidly (over 1985 levels) than those of petroleum fuels. The latter forecast is based on the belief that the federal government will have relaxed its current policy of keeping the natural gas price below that of its equivalent in crude oil.

Given fertilizer's high energy content (mainly natural gas) and its importance in Ontario agriculture, a price forecast for anhydrous ammonia, a widely used nitrogen-based fertilizer, has also been included.

Details of these forecasts are supplied in Table 2.2. in current dollars, with an average inflation rate over the forecast period of 8 per cent.

TABLE 2.2

Fuel and fertilizer price forecasts: 1985 and 2000

	Crude oil	Natural gas	Electricity	Gasoline (regular)	Diesel fuel	#2 light fuel oil	#6 heavy fuel oil	Propane	Anhydrous ammonia
	($/bbl)	($/Mcf)	(Cents/kWh)	($/Litre)					($/ton)
1980	20.33	2.90	3.77	0.29	0.29	0.19	0.17	0.15	335
1985	42.30-47.70	4.90-5.50	6.30	0.52-0.56	0.52-0.57	0.38-0.41	0.27-0.38	0.26-0.28	392
2000	169.00-187.00	21.64-27.40	16.2-19.0	1.86-1.99	1.86-2.04	1.40-1.51	1.06-1.51	0.98-1.12	1222

NOTE: All prices are in current dollars, i.e. 1985 prices in 1985 dollars, 2000 prices in 2000 dollars. Prices are as follows: anhydrous ammonia: Southern Ontario retail price; crude oil: Toronto delivered; natural gas: Toronto City Gate; electricity average revenue per kWh of power sold to farm customers; propane: Ontario estimated retail price; all others: Toronto retail. 1980 prices are those prevailing in November 1980.

SOURCE: For fuels, Ministry of Energy, Strategic Planning and Analysis Group. For anhydrous ammonia, Research Report 1.

Methodology used in price forecasting

Crude oil. The price forecasts for gasoline, diesel fuel, light fuel oil (No. 2 domestic) and heavy fuel oil (No. 6) are all based on a forecast of crude oil prices that in turn is based largely on the scenario presented in the federal government's National Energy Program. On that basis (through future negotiations between the federal and Alberta governments may change the numbers) it is a relatively simple task to estimate the cost of crude oil delivered to Toronto as far ahead as 1983. Beyond that point the federal government, while it has provided a schedule of increases for the wellhead price of crude oil, has not revealed its intentions concerning the petroleum compensation charge (PCC) which must be added to the wellhead price to obtain the blended price.

To obtain a forecast for 1985, it was therefore necessary to make assumptions about the level of the PCC. Two alternative assumptions were made: (a) that it continues to increase at $2.50 annually (as it is scheduled to do during 1981-3), and (b) that it remains unchanged at $10.05 after 1983. Applying the assumed inflation rate to the cost of transporting the oil from Alberta we arrive at a forecast range of 1985 crude oil prices (Toronto delivered) of $42.30 - $47.70. The corresponding price in November 1980 stood at about $20.50. This represents an increase of between 106 and 133 per cent, or between 15.5 and 18.4 per cent compounded annually. If the effects of inflation are removed, the price of crude oil will rise in real terms between 6.5 and 9.5 per cent annually from now to 1985.

In the National Energy Program, the federal government announced a goal of crude oil self-sufficiency for Canada by 1990. Also by 1990, or shortly thereafter, Canadian crude oil will be sold at the lower of the current reference price for tar sands oil adjusted annually for inflation and the world price. The Ministry of Energy's forecast for 2000 uses the reference price.

Gasoline and diesel fuel. For the forecast, the price of gasoline was broken into a crude oil component and all other components. The latter includes federal and provincial taxes and retail and distribution margins. While the crude oil component is assumed to rise in step with the price of crude oil, the other elements in the gasoline price are forecast to rise at the rate of inflation. On these assumptions, the retail price of gasoline in Toronto in 1985 will be between 52 and 56 cents a litre. By 2000 the price will be close to $2.00 a litre.

For diesel fuel, two scenarios have been developed: one involves the maintaining of parity with gasoline through the forecast period, and the other assumes that diesel fuel prices (in 1980 dollars) rise to 1 cent a litre above gasoline by 1985 and stay there for the remainder of the period.

Fuel oil. To forecast the retail price of light fuel oil, a method similar to that used for gasoline was employed. The crude oil component was raised in step with the price of crude, while transport and distribution margins were raised at the predicted rate of inflation.

Forecasting the price of heavy fuel oil is especially difficult since its price fluctuates much more violently than other petroleum prices. This is largely due to the fact that Ontario exports much of its heavy fuel oil production, so prices are heavily influenced by conditions in world markets. The relationship between the prices of heavy fuel oil and crude oil over the past twenty years was examined. A range of future prices was then developed with the lower end based on heavy fuel oil at 95 per cent of the crude oil price and the upper end on a 135 per cent heavy/crude ratio. In both bases the mid-point of the crude oil price range was used.

Natural gas. Price forecasts for 1985 were derived largely from the National Energy Program scenario, which plotted the Toronto City Gate price of gas to August 1983. Increases in the price of natural gas between now and 1983 will have two components: a rise of $0.15 per thousand cubic feet (Mcf) for every $1 rise in the wellhead price of crude oil (this increase did not occur in 1981); and a tax of $0.30/Mcf introduced on 1 November 1980 and to be increased by $0.15/Mcf in each of the next three years.

According to the National Energy Program price schedule, these two components will bring the price of natural gas in 1983 to 67 per cent of the cost of the energy equivalent in crude oil. For purposes of the forecast, the 67 per cent was applied to the 1985 forecast price range for crude oil. Thus, the price of natural gas at the Toronto City Gate will rise to between $5 and $5.50 in 1985.

The federal government maintains the price of natural gas on an energy-content basis below that of oil to encourage consumers to switch to gas as part of its goal of oil self-sufficiency by 1990. Once a significant degree of conversion has been completed, the need for this price discrepancy will have diminished significantly, if it has not disappeared. In addition, it is expected that by the year 2000 much of Canada's gas supply will come, not from Alberta, but from more expensive Arctic and offshore deposits. This suggests that gas prices by the year 2000 might approach twice those of oil on an energy-equivalent basis. However, because competition from electricity will help keep gas prices down, the forecast price range for gas in the year 2000 is based on 75 per cent and 85 per cent energy equivalence to oil.

Propane. The retail price of propane in Ontario is the Alberta price plus the cost of transportation, fractionation, and storage at Sarnia, plus the cost of transportation to bulk storage in Ontario, plus the cost of local distribution to customer facilities and markup by the distribution company.

Since three-quarters of Canadian propane is 'stripped' from natural gas, the prices of the two fuels are closely related. The forecast analysed the Ontario retail price into a natural gas component, which was raised along with the price of natural gas, and all other components, which were assumed to increase at the rate of inflation. The low and high scenarios are based on the lower and upper ends respectively of the forecast price range for gas.

Electricity. The low scenario for future electricity prices comes from Ontario Hydro. It shows real costs rising at roughly 1 per cent until 1985 and falling thereafter. It was felt that a reasonable alternative scenario would be to assume constant real prices after 1985.

Anhydrous ammonia. This forecast makes use of the above fuel price predictions, but specific assumptions have been made about improved energy efficiency in the production process, so that the impact of future fuel price increases is reduced to some extent. Although the predicted increase for 1985 over 1980 may seem small, the price jumped by 56 per cent between 1978 and 1980.

ONTARIO ENERGY DEMAND AND SUPPLY GOALS

National crude oil self-sufficiency

In its policy document published in September 1979, Energy Security for the Eighties: A Policy for Ontario, the Government of Ontario supported a national goal of crude oil self-sufficiency for Canada by 1995. Since October 1979 a number of factors suggest that the target date should be moved forward to 1990. Such a move is possible because of new offshore and frontier discoveries in Canada, the potential of heavy oil and enhanced recovery, and the effects on demand of conservation and oil substitution. It is desirable because Canada still imports some 20 per cent of its crude oil requirements, and reducing our dependence on foreign oil from politically unstable regions should be a national priority for the decade ahead. Crude oil self-sufficiency for Canada by 1990 is a goal of the National Energy Program.

As part of the province's contribution to the achievement of the goal of national crude oil self-sufficiency by 1990, conservation and substitution targets have been established by the Ministry of Energy for each of the four sectors (Figure 2.6).

Figure 2.6 Ontario conservation and substitution targets

Energy conservation targets	Oil substitution targets
Transportation	
• 50 per cent improvement in passenger miles per unit fuel consumption and for freight a 20 per cent reduction in unit fuel consumption per ton mile by 1995 over 1980 • For Ontario government fleet, 10 per cent improvement in energy efficiency by 1983 over 1980	• Reduce oil share to 90 per cent by 1995
Residential	
• 30 per cent improvement in average household energy efficiency by 1995 over 1980	• Reduce oil share to 10 per cent by 1990
Commercial	
• 20 per cent improvement in commercial building energy efficiency by 1995 over 1980 • For Ontario government buildings, 26 per cent reduction in energy consumed by 1985 over 1976	• Reduce oil share to 10 per cent by 1990
Industrial	
• 25 per cent reduction in energy per unit output by 1985 over 1975	• Reduce oil share to 10 per cent by 1990

The average growth in secondary energy consumption in Ontario between 1973 and 1978 was 2.3 per cent annually. If the conservation targets are reached, growth in secondary energy consumption in Ontario between 1980 and 1995 will average 1 per cent annually.

Indigenous energy production targets for Ontario

To increase provincial energy self-sufficiency Ontario has established the following targets:

- To produce 37.5 per cent of Ontario's primary energy in 1995 from indigenous provincial sources versus 23.5 per cent in 1980
- To produce at least 5 per cent of Ontario's total primary energy requirements by 1995 from renewable and recoverable energy resources such as municipal wastes, forest wastes, industrial waste heat, agricultural crop residues, poplar plantations, synthetic liquid fuels from biomass, and solar applications. This will represent an energy-equivalent saving of approximately 42 million barrels of oil to the province.

AGRICULTURAL ENERGY DEMAND PROJECTIONS

In formulating its own estimates of increased energy demand, the Committee took account of the following projections developed by its researchers.

Field crops

The four main variables which determine the agricultural energy demand and cost scenarios for 1985 and 2000 are as follows:

- projected increases in agricultural productivity on a per hectare or per animal basis,
- projected increases in total food requirements in Ontario,
- the effects of energy conservation and increased efficiency due to improved design of energy-consuming equipment (see next chapter), and
- energy price scenarios for 1985 and 2000.

Based on the above assumptions the research indicates that, despite an increase in area, a decrease in total energy consumption is projected because of the implementation of agricultural conservation measures and productivity improvements (Table 2.3). Total energy consumption in crop production could fall by nearly 7 per cent between 1978 and 1985 and by 24 per cent between 1978 and 2000 if a broadly based conservation program is successfully implemented. If energy efficiency measures are not implemented, overall energy use per unit of output would probably remain at about current levels or increase slightly.

The electricity and natural gas prices given in the 1985 scenario are shown in the research projections to increase to a lesser extent than fuel oil and diesel fuel, and the same is true for the year 2000, except that natural gas prices increase slightly less than fuel oil (over the 1978 price), and for this reason natural gas accounts for a slightly smaller percentage of total crop energy costs in 1985 and 2000 than in 1978, as shown in Table 2.4.

Transportation energy costs for 1985 and 2000 may diminish in relation for production energy costs. This is primarily because the scenario shows greater reductions in fuel use for transportation (on a per unit of commodity basis) than for production. However, the importance of transportation should not be minimized, since transportation energy costs exceed production energy costs in the 1985 and 2000 scenarios for a number of crops, such as rutabagas, processing tomatoes, and cabbage. Table 2.5 shows that transportation energy costs could fall from 10 per cent of total production plus transportation costs to about 8 per cent in 2000.

Animal production

The variables determining energy requirements for animal production are the same as those for crops. As in the case of crop production, the research suggests the total amount of energy per unit of output consumed for animal production in 2000 could be 17 per cent less than in 1985 and 21 per cent less than in 1978. This result is, of course, highly contingent upon the success of a strong energy conservation program. Table 2.6 and Appendix J summarize these reductions for each fuel type.

TABLE 2.3

Total energy requirements for production of twenty-seven crops in Ontario 1978, 1985, and 2000

Energy type	1978		1985		2000	
	PJ	%	PJ	%	PJ	%
Natural gas	16.4	49.8	15.4	50.0	12.2	48.6
Fuel oil	4.3	13.0	3.9	12.7	3.3	13.1
Diesel fuel	9.0	27.3	8.4	27.3	7.0	27.9
Gasoline	1.1	3.3	1.0	3.2	0.8	3.2
Propane	0.8	2.4	0.8	2.6	0.6	2.4
Electricity	0.9	2.7	0.9	2.9	0.8	3.2
Formulation (pesticides)	0.5	1.5	0.4	1.3	0.4	1.6
Total	33.0	100.0	30.8	100.0	25.1	100.0

NOTE: Projections assume successful energy conservation and substitution program is implemented. Natural gas includes fertilizer requirements but excludes greenhouses.

SOURCE: Research Report 1, Tables III.2.1 and III.2.2

TABLE 2.4

Total energy dollar expenditure for crop production in Ontario 1978, 1985, and 2000 (millions of current dollars)

Fuel type	1978	1985		2000	
	Actual	Low-price scenario	High-price scenario	Low-price scenario	High-price scenario
Natural gas	38.1	65.7	73.9	233.5	293.0
Fuel oil	11.6	32.4	35.4	99.2	107.3
Diesel fuel	38.1	88.4	97.8	265.8	290.4
Gasoline	5.6	13.0	14.0	37.9	40.5
Propane	3.5	7.5	8.0	21.5	24.7
Electricity	4.8	8.2	8.2	17.4	20.5
Formulation	-	-	-	-	-
Total	101.7	215.2	237.3	675.3	776.4

SOURCE: Research Report 1

TABLE 2.5

Total production and transportation costs for crops in Ontario 1985 and 2000, high-price scenario (thousands of current dollars)

	1985		2000	
	Total energy related costs of production	Transportation cost	Total energy related costs of production	Transportation cost
Barley, mixed grains	21 454	2 490	73 139	6 543
Oats	6 882	994	22 722	2 611
Winter wheat rye	12 267	1 146	42 978	3 018
Grain corn	74 904	5 264	246 767	12 509
Soybeans	9 057	622	28 819	1 595
White beans	225	86	6 990	219
Apples	1 454	1 329	4 586	3 226
Grapes	1 291	582	4 014	1 413
Peaches	393	270	1 209	655
Cabbage, cauliflower	379	628	1 127	1 525
Carrots	288	586	844	1 421
Celery	50	131	157	317
Cucumbers	292	367	882	892
Sweet corn - fresh	190	73	611	178
Sweet corn - processing	1 215	1 429	3 909	3 468
Lettuce	66	164	205	397
Onions	371	543	1 162	1 327
Peas	448	2 649	1 321	6 429
Potatoes	3 527	2 658	10 850	6 443
Rutabagas	166	530	495	1 286
Tomatoes - fresh	173	77	548	186
Tomatoes - processing	1 382	3 514	4 157	8 528
Sub total	136 474	26 132	457 492	64 186
Crops not requiring transport	98 630		318 856	
Total	235 104	26 132	776 348	64 186

NOTE: Energy includes fertilizer and pesticides.

SOURCE: Research Report 1, Tables III 2.2(A) and (B) and Table III 4.2

TABLE 2.6

Total energy requirements for animal production 1978, 1985, and 2000

Energy type	1978		1985		2000	
	TJ	%	TJ	%	TJ	%
Natural gas	871	12.2	825	12.1	707	12.5
Fuel oil	585	8.1	526	7.7	451	8.0
Diesel fuel	1 802	25.3	1 851	27.0	1 651	29.2
Gasoline	126	1.8	114	1.7	85	1.5
Propane	764	10.7	679	9.9	461	8.1
Electricity	2 990	41.9	2 847	41.6	2 307	40.7
Total	7 135	100.0	6 842	100.0	5 662	100.0

SOURCE: Research Report 1, Tables IV.2.1 (A) and (B) and IV.2.2 (A) and (B)

Energy costs in 1985 and 2000 as a percentage of essential material inputs and total production costs are generally shown to decrease in animal production in contrast with crop production. In 1978 energy costs were estimated to be 4 per cent of total production costs. In 1985 the forecast is 3.2 per cent, falling to about 2.8 per cent in 2000. There are two main reasons for this. The first is that energy reductions are greater for animal products than for field crops. Secondly, electricity accounts for a much larger percentage of total livestock energy inputs (42 per cent as against 3 per cent for crops), and electricity prices are forecast to increase least. Only in the case of poultry do energy costs increase in relative importance, and this only occurs up to 1985, with energy costs showing a return to the 1978 level of importance in 2000.

A pronounced shift occurs in the percentage of total energy expenditure each fuel type represents in 1985 and 2000 compared to 1978 (Table 2.7). For example, electricity falls from 62 per cent of total energy cost in 1978 to 48 per cent in 2000, while diesel fuel rises from 20 per cent to 28 per cent despite a 13 per cent drop in consumption. That is because electricity price increases are forecast to rise at a slower rate than other energy prices, while electricity consumption is decreasing from 1978 levels at about the same rate as that of other energy types. The result is a decrease in the relative importance of electricity costs by 14 percentage points by 2000, with the remaining adjustment yielding slight increases in furnace oil, natural gas, and propane. Electricity expenditures for dairy cows decline from 30 per cent of total animal energy expenses in Ontario to 26 per cent and 22 per cent in 1985 and 2000 respectively. However, despite this decrease in relative importance, electricity costs for dairy herds remain the largest single energy cost input for livestock production in the province. Appendices K and L indicate that, while an actual fuel consumption decrease is shown for animal commodities, transportation energy costs as a percentage of the sum of production energy and transport energy costs fall slightly for all products except milk and pork, which rise slightly between 1985 and 2000. This indicates that transport energy savings for most products are even greater than on-farm energy savings.

TABLE 2.7

Total energy expenditure for animal production in Ontario 1978, 1985, and 2000 (millions of current dollars)

	1978	1985		2000	
Fuel type	Actual	Low price scenario	High price scenario	Low price scenario	High price scenario
Natural gas	2 090	3 671	4 076	13 713	17 229
Fuel oil	1 706	4 799	5 242	14 923	16 164
Diesel fuel	8 157	19 606	21 480	62 404	68 186
Gasoline	780	1 689	1 809	4 549	4 862
Propane	2 911	6 667	7 063	16 927	19 431
Electricity	25 757	47 651	47 651	99 383	116 537
Total	41 401	84 083	87 321	211 899	242 409

SOURCE: Research Report 1

CHAPTER 3

STRATEGIC DIRECTIONS

ENERGY EFFICIENCY IN AGRICULTURAL PRODUCTION - OPPORTUNITIES

This list of possible measures to improve energy efficiency in farm operations is long, and the potential savings are substantial. The Committee's research identified possible savings in virtually every farm operation. Table 3.1 summarizes the potential savings in percentage terms for seven major categories: crop production, animal housing, feed preparation, grain drying, transportation, and fertility management. Research Report 2 gives the details of energy reductions that have been achieved in demonstration or on-farm situations. It also suggests some of the side-effects of energy conservation such as improved feed conversion in better-controlled animal environments, and outlines what costs and payback periods are commonly encountered.

This study of energy efficiency has been concerned primarily with the best expectations for on-farm energy conservation. However, Table 3.1 shows both the possible and the probable effects of conservation in 1985 and 2000. The 'probable' scenario still assumes an accelerated encouragement of conservation by government, extension services, farm organizations, and educational institutions but recognizes that certain constraints, such as insufficient financial payback, will prevent realization of the full potential. The predicted realizable savings are only rough estimates in many instances, but they are useful in setting overall conservation targets for the farm sector.

Many of these conservation measures are already widely known and simply need better promotion and perhaps further price increases to warrant implementation. For example, gasoline-to-diesel conversion and better use of machines are commonly understood energy-saving practices and fairly straightforward to implement. On the other hand, changes in fertilizer application and manure management are more complicated and contain more practical uncertainties. Some of the potential areas of savings have not been quantified because of a lack of data. This is particularly the case with grain drying and storage, where only two of six potential energy conservation measures could be quantified.

TABLE 3.1

Energy efficiency potential on farms in Ontario (percentages)

Farm operation	1985		2000	
	Total potential saving	Probable achievable saving	Total potential saving	Probable achievable saving
Crop production				
- Gasoline-to-diesel conversion (diesel rises from 80% to 85% in 1985 and 90% in 1990)				
. increased diesel consumption	(+6)		(+19)	
. decreased gas consumption	(-8)		(-26)	
- Increased efficiency of operation	22	5	22	10
- Combined field operations	5	1	10	3
- Improved engine tune & design	6	1	15	10
- Radial tires	2-6	2	6	6
- Improved tillage (reduced tillage, reduced depth & speed)	20-50	5	20-50	20
Total saving	40-50	10	50-60	35
Animal housing				
All species: Electricity				
- high efficiency motors & lighting	8	4	20	15
Dairy: Electricity				
- heat reclaiming from milk	12	8	15	15
Hog: Electricity[a]				
- heating-ventilation interlock	10	2	10	8
- ventilation heat reclaim	15	3	20	16
- thermostat all heat sources	10	2	10	8
- insulation	8	3	8	8
Total saving	36	8	40	33

TABLE 3.1 cont'd

Farm operation	1985 Total potential saving	1985 Probable achievable saving	2000 Total potential saving	2000 Probable achievable saving
: Heating fuels				
- heating-ventilation interlock	15	3	15	12
- ventilation heat reclaim	23	5	30	24
- increased burner efficiency[b]	14	3	14	11
- insulation	12	5	12	12
Total saving	49	12	54	45
Poultry[c]: Electricity				
- heating-ventilation interlock	10	2	10	8
- insulation	8	3	8	8
Total saving	17	5	17	15
: Heating fuels				
- heating-ventilation interlock	15	3	15	12
- insulation	12	5	12	12
- increased burner efficiency	14	3	14	11
Total saving	35	9	35	29
Feed preparation (feed mills)				
Boiler fuel	10	7	18	15
Delivery trucks	50	20	60	50
Electricity	5	3	25	15
Grain drying and storage				
- Switch to high-moisture silos				
- Switch to crib drying		3		10
- Combination drying				
- Low temperature drying				
- Reduced over-drying				
- Improved dryer efficiency	11			32
Total saving		10		35
Transportation				
- Reduced speed limits 65-55 mph (gal/mile)	7	2	7	7
- Automatic fans	7	3	7	7
- Streamlining, airfoils	5	3	5	5
- Engine efficiency, design	15	10	25	25
- Radial tires	6	2	6	6
- Increased payloads. GVW (gal/ton)	10	4	10	10
- Rationalized routing (gal/ton)				
Total saving	50	20	60	50

TABLE 3.1 cont'd

Fertility management[d]		
- Soil conservation practices	15	15
- Nitrogen fixation . rotation, intercropping		
- Improved prescription of nutrient requirements		
- Improved manure storage	10	20
- Improved manure application	25	30
- Anaerobic digestion	5	20
- Composting		
- Nitrification inhibition		

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a. Two-thirds of electricity is for heat. Half of heat is space heat, half is radiant spot heat. In 1985, 75% of barns will be eligible for upgrading; in 2000, 100% will be.

b. Natural gas technological improvements have been transferred to propane.

c. Poultry = boiler barns. Additional improvements not listed here are possible for layer operations.

d. These are nitrogen savings except for soil conservation practices, which are fertility savings.

NOTE: Total potential savings reflect technical possibilities without regard for economics. Probable achievable savings reflect economic and qualitative factors limiting the achievement to technical potential. Because of interactive effects, total savings are usually less than the sum of individual savings.

CROP PRODUCTION

When fertilizer is dealt with as a separate subject, energy efficiency in field crop production concerns mainly the management of machinery and tillage practices.

Gasoline-diesel conversion

Because of the efficiency of diesel engines and the superior calorific value of diesel fuel, diesel engines require only 7.3 L of fuel to perform the same work as a gasoline engine requiring 10 L. It is estimated that 80 per cent of mobile farm power is already provided by diesel engines. An increase in 1985 to 85 per cent and in 2000 to 95 per cent diesel power would reduce overall fuel requirements for tractors by 2 per cent in 1985 at 1978 production levels and by 7 per cent in 2000.

Increased efficiency of operation

Education and extension efforts leading to improved equipment operation could result in fuel savings up to 22 per cent based on current practices and fuel consumption. The sources of these improvements would be loading, gearing, idling, and wheel slip (see Research Report 2 for details).

The use of large tractors for light work can be inefficient. For example, 6.2 and 2.7 litres of fuel per acre were used by 82 hp and 64 hp tractors respectively operating under identical conditions. Of course regional and individual factors must also be taken into account by the farmer making the decision.

Improved tillage

Headlands. Fuel consumption while turning on headlands can represent 10 per cent of the total fuel consumption. This loss of useful energy can be reduced by working in the longest possible direction or by using an around-the-field technique.

Speed. Because many tractors are overpowered for their tillage tools, farmers often operate equipment at too high a speed. Slowing down from 11 km/h to 8 km/h can save 28 per cent in fuel, and from 8 to 5.6 km/h can save 16 per cent.

Tillage depth. The depth of tillage operations should be reduced to the minimum with which crop yield can be maintained. On some soils an increased depth of ploughing actually reduces crop yields as well as increasing fuel consumption.

Reduced tillage

The elimination of unnecessary tillage gives the single greatest saving in fuel for field operations. The fall secondary tillage common in Ontario is largely unnecessary.

For example, if average tillage practices consume 50 L/ha in total, the elimination of fall discing at 6 L/ha would reduce consumption by about 12 per cent.

Elimination of unnecessary mouldboard ploughing at 15 L/ha would reduce consumption of 50 L/ha by 30 per cent. The elimination of harrowing would save 1-5 L/ha or 2 to 9 per cent.

By direct combining of grain, swathing can be eliminated, to save 3.5 L/ha and reduce grain harvesting energy by 30 per cent. An analysis of nine tillage systems used to produce corn in the United States showed that the number of separate field operations can vary from one to eight, and that total diesel fuel consumed can vary between 5.5 L/ha and 42 L/ha (Research Report 2).

Combined operations

Because up to 60 per cent of the fuel consumed during tillage may be used merely to propel the tractor itself across the field, it is advantageous to combine tillage and seeding or several tillage operations into a single-pass operation.

Tractor and equipment maintenance

Fuel conservation depends largely on the care, adjustment, and operation of tractors and other equipment. For example, dirty or faulty sparkplugs can increase fuel consumption up to 15 per cent, whereas regular tuneups can keep fuel consumption down by 10 to 15 per cent.

Improper adjustment of mouldboard ploughs increases the draught and may result in 15 per cent fuel wastage without improving the quality of ploughing.

Radial tires

The savings from the use of radial tires on farm equipment in Ontario are estimated in the range of 2 to 6 per cent, although savings of up to 15 per cent have been confirmed in Nebraska.

Conclusion

There are two aspects to energy efficiency in machinery management: what the equipment is used for and how it is handled and maintained. Both aspects have energy savings potential. In field operations, the savings resulting from shallower ploughing, reduced tillage, and even no tillage at all are obvious and well proven. While research may be necessary to refine these possibilities and clarify standards, some of the techniques are known now and only require promotion in the farming community.

Other energy efficiencies can be achieved through the proper matching of motive power to equipment and the use of equipment appropriate to the actual job to be done. If changes in field operations such as ploughing occur, there will be a corresponding need for information on equipment that will meet the new standards. Finally, there is a general need for comparisons of types of equipment in terms of durability, fuel consumption in various types of operation, and so on. Such information, though having little immediate effect on efficiency, should in the long term influence the selection of more energy-efficient machinery as current equipment is replaced. Thus an integrated package of information should be developed covering operations, standards, and performance. This package could be developed for presentation in short courses and seminars on conservation practices on the farm, and it should stress the potential dollar savings of adopting energy-efficient practices.

GRAIN DRYING AND STORAGE

Drying represents a large part of the energy inputs for Ontario's 169 million bu. annual production of grain corn. About 118 million bu. of this crop is artifically dried, about 70 per cent in commercial dryers and the balance in farm dryers.

The drying energy requirement varies greatly depending on the variety of corn and on the moisture content of the grain at harvest and at completion of drying. In Ontario at harvest the range is 20 - 40 per cent moisture content, thus requiring from 5 to 25 points of drying to reach 15 per cent. The final moisture content may be as low as 13 per cent if the corn is intended for long-term storage.

On average, corn in Ontario is dried to about 15 per cent moisture content. This requires from 4600 to 5100 KJ in energy per kilogram of water removed, not including the energy used to move grain and air, which adds another 15 per cent. The energy needed for drying varies greatly with dryer and size and can be doubled with a wet harvest and drying season. Most commercial dryers use natural gas, whereas most on-farm dryers use propane or heating oil.

There are various ways to reduce energy requirements for corn drying, such as replacement of old dryers with more efficient models that use up to 35 per cent less energy. Other methods of drying that can reduce energy requirements are discussed next.

Dryeration

Dryeration systems operate more efficiently than cross-flow dryers. Corn to be held in long-term storage is conventionally fired until it has 18 or 19 per cent moisture content, then placed in adjacent dryeration bins where an additional 2.5 per cent reduction occurs at an intermediate temperature without the use of fuel. The corn is then aerated throughout the storage period in conventional grain bins, reaching the final desired moisture content. In the United States energy savings of 32 per cent compared to regular high-temperature drying are possible because the high heat requirement for removing the last few points of moisture has been avoided.

Low-temperature drying

Low-temperature or natural-air drying requires 2500–3250 KJ per kilogram of water removed and can be used to dry or finish grain at less than 25 per cent moisture content. A small temperature rise of a few degrees with high air-flow rates can slowly reduce grain moisture content three to five points in twenty to thirty days. Faster drying takes place when the drying air is slightly warmer, as in solar drying systems, and in warmer, drier weather conditions. If the relative humidity is 80 to 85 per cent, the required temperature difference is 3 to 4°C. Under 75 per cent relative humidity, 1 to 2°C temperature differences are feasible.

Combination drying

The drying alternative often discussed for Ontario is combination drying, in which the grain is high-temperature-dried down to about 20 per cent moisture content, then transferred to low-temperature bins for final drying. The saving in propane is somewhat offset by the requirement for more electricity for aeration and the consequent peak load demand during the two- or three-month drying season. In a comparison of typical cases, however, 100 bushels of corn are dried from 28 per cent to 15 per cent moisture content using 2.998 GJ with high-temperature drying and only 0.967 GJ by combination drying.

Crib drying

Depending on atmospheric conditions, corn harvested below 25 to 35 per cent moisture content - which may constitute one-half of Ontario's corn harvest - can be air-dried as ear corn in cribs. This was common practice in Ontario until the early 1960s. As well as eliminating drying energy, this process replaces the combine (13.75 L/ha) with the simpler and more fuel-efficient corn picker (11.13 L/ha). However, better equipment must be developed to handle and store cob corn.

If half the corn now dried on farms were crib-dried, the saving would be about 223 000 litres of diesel fuel and 15 million litres of propane. Other possible ways of reducing energy for drying include management practices such as the use of high-moisture corn as feed, caution against overdrying of corn, proper selection of corn varieties, adjustment of combines to eliminate waste that should not be dried, and recirculation of dryer air.

Given this array of possibilities, the Committee estimates that the current industry average of 5100 KJ per kilogram of water removed will be reduced to 4600 KJ by 1985 and to 3500 KJ by 1995. If the same proportion of corn is dried in those years as now, then the propane and natural gas saved will be 10 per cent in 1986 and 35 per cent in 2000 compared to current rates of consumption. There would be only a slight increase in electricity demand.

If all eligible corn were dried in cribs, the drying energy could be reduced by half below current rates. Even a limited implementation of cribbing would result in a 3 per cent reduction in total drying energy by 1985 and 10 per cent by 2000.

Conclusion

Grain drying and storage, a major energy user in farmstead operations, presents important opportunities for improved energy efficiency. New dryers are almost twice as efficient as old models, so there is a large potential in replacement of old units. Given the magnitude of potential savings, an investment incentive program to encourage dryer replacement would be desirable. Further energy reductions are possible through better management of the drying process. Reducing the amount of grain dried and increasing the percentage of moisture in stored grain are both feasible methods of reducing energy input. As in other cases, farmers need to be informed of the energy savings possible.

ANIMAL HOUSING

Space heating accounts for most of the fuel oil consumed in livestock production in Ontario.

Insulation and infiltration control

By upgrading building shell insulation and reducing outside air infiltration, it is estimated that overall heating energy could be reduced by 6 per cent by 1985 and 10 per cent by 1995 in brooder and farrowing barns. Individual operations may have a potential much greater than this. Weatherstripping and caulking provide a very early payback; insulation takes considerably longer because of the high cost.

In 1978 it was estimated that half of all poultry barns were uninsulated or underinsulated. At present, approximately 30 per cent of Ontario's 1000 poultry barns have less than the recommended insulation of R28 in ceilings, R20 in walls, and R8 on perimeter locations. In hog barns, where the situation is comparable, Ontario Hydro has estimated that insulation at recommended levels could greatly reduce the need for supplementary heating. For a typical, underinsulated, 400-hog barn in winter, this could represent a saving of nearly 3.5 litres of fuel oil an hour throughout the heating season.

For an underinsulated poultry barn (R-7 ceiling, R-5 walls), typical of those in Ontario, a payback period of about two years for ceiling insulation and of 5.2 years for wall insulation may be expected. Adding R-4 ceiling insulation at a cost of $2747 would save 8600L of fuel oil a year. Adding R-7 foam to the walls at a cost of $5900 would save 6800L a year.

Space heating

High-efficiency natural gas furnaces have been developed with efficiencies of up to 90 per cent, compared to the usual 70 per cent. If this technology is applied to other gaseous fuel heating, with efficiency improvements of 70 to 80 per cent, energy savings of 14 per cent would be possible. This would benefit primarily poultry and hog farms with propane heating. Corresponding improvements in burner and heat exchanger design are expected for oil furnaces.

Innovative gas-fired infra-red heating systems offer the same combustion efficiencies as the best oil-fired broiler system (90 per cent) but have the additional advantage of providing radiant heat, warming animals and objects with less energy than is required to heat the entire space.

Individual radiant heat units can provide thermostatically controlled spot heating. The addition of thermostatic control to conventional heat lamps can reduce farrowing pig electricity requirements by 30 per cent. In a 100-sow farrowing operation with one heat lamp per sow in use half the year, this saving would be about 32 850 kWh annually, worth $1238. The cost of controllers would be approximately $1900 without wiring. The payback period would therefore be about two years.

A simple no-cost measure is to replace 250 W bulbs with 175 W bulbs where the former have proved to be too hot.

Interlock controls

Interlock controls that prevent supplementary heat and second-stage ventilation from operating simultaneously can reduce heating loads in hog and calf barns with 'low inertia' heating systems by 30 per cent. Such controls perform best in mild weather. Of Ontario's modern hog farrowing barns, 90 per cent are electrically heated, using an average of 40 kWh per pig annually, about two-thirds of the total energy consumed on hog farms.

Heat exchangers

The heat recovered from ventilation exhaust from a farrowing barn has been measured to be 33 per cent of the total heating load. For heat exchangers to work this efficiently in agricultural buildings, they must be protected from ice and dirt accumulation. At this rate of efficiency the overall potential for reduced consumption in Ontario hog barns is 424 500 litres of propane. Only the large operations, on which 75 per cent of hogs are produced, are considered eligible candidates for heat exchange.

Programmed ventilation

Without a systematic approach in which ventilation is related to moisture removal requirements and ventilation rates are monitored, it is not possible to evaluate the potential for improvement in current ventilation practices. For example, while it is possible to adjust ventilation progressively to the requirements of growing birds in brooder barns in order to eliminate overventilation in the early weeks, this practice is uncommon and not well tested.

Open housing

Controlled environment housing is sometimes unnecessary for certain livestock, such as sheep and cattle. In this case, open housing can altogether eliminate the need for ventilation and supplementary heat energy.

Production scheduling

Since much of the energy requirement of livestock production is for heat in winter, both 'feed-energy' animal heat and supplementary heat, rescheduling some winter production to other seasons could reduce total feed and heat energy demand. To maintain meat supplies in winter would require the installation of more refrigerated storage, which in winter is not energy-intensive.

Lighting

Lighting levels in poultry broiler barns can be reduced up to 70 per cent without affecting productivity by installing lower wattage bulbs, dimmers, or time clocks.

Motors

A substantial proportion of farm electricity is used for motors. New high-efficiency motors are capable of efficiencies of 90 per cent compared to 55-65 per cent for conventional small motors. This represents a potential reduction in power requirement of 15-25 per cent for all farm motors.

Conclusion

Most of the methods for saving energy in farm buildings (ventilation, lighting, heating and cooling) are well known and do not require research effort.

However, standards and design guidelines are required. Some well-developed technologies that may only now be economically feasible, such as heat recovery in livestock barns using heat exchangers, require some on-farm demonstration. Again, the dissemination of information on economic and reliable equipment for farm buildings is relatively expensive and requires financial incentives to be attractive to farmers.

FERTILITY MANAGEMENT

Fertilizers are more efficient on better soils. The best productivity or output from fertilizer inputs will be achieved on the best land. However, this problem is more one of land management than fertilizer management and does not need further discussion here.

Soil erosion and costs

Soil erosion represents an important energy cost because it removes nutrients, thus increasing the need for energy-based fertilizer inputs, reduces tilth, thus increasing the need for more tillage to prepare a good seed bed, and decreases water infiltration, thus decreasing yields. Yield reduction from one inch of soil erosion can be 9.8 bu/ha of corn, 5.9 bu/ha of oats, and 6.1 bu/ha of soybeans.

Soil losses can be decreased by reducing tillage and introducing crop rotations, but the costs in terms of lost income can be much greater than the apparent cost of resulting soil erosion. Conservation methods can greatly reduce soil erosion, and, as energy input costs grow, more energy-efficient practices may be more attractive. Table 3.2 shows some of the potential for reducing erosion.

Nitrogen fixation

The contribution of nitrogen by ploughing down legumes such as alfalfa, trefoil, and red clover is shown in Table 3.3. With adequate legume content, Ontario's 1.15 million hectares of hay crop, ploughed under on average every four years, could contribute 31 300 tonnes of nitrogen, or 23 per cent of the current estimated use of nitrogen in Ontario.

The feasibility of using legumes to provide most of the nitrogen for high-yielding corn hybrids is substantiated by several American studies (though such practices do of course restrict corn acreage). The amount of nitrogen produced by legume crops alone is often insufficient to produce maximum yields of crops such as corn, except where restricted water supply may have already limited crop yields.

TABLE 3.2

Potential for decreased soil loss

Crop	Conventional farm practice	Soil loss (tonnes/ha)	Soil conservation method	Soil loss (tonnes/ha)
Potatoes	Plough straight lines	32.0	Contour plough*	0.22
Corn	Continuous corn	43.8	Crop rotations (corn-wheat-clover)	6.0
Corn	No manure	49.1	Manure added (39.8 tonnes/ha with 9% slope)	10.5
All crops	Plough, disc, harrow, plant	23.8	Minimum tillage, plant	7.6

*requires 7 per cent more fuel and time

SOURCE: D. Piemental et al, 'Land degradation: effects on food and energy resources,' Science, Oct. 1976

TABLE 3.3

Nitrogen contribution by ploughing down legumes

Legume content of sod %	Nitrogen contribution to soil when ploughed under (kg/ha)
50	108
33-50	55
33	0

SOURCE: OMAF Publication 296, Field Crop Recommendations 1980

The amount of crop rotation currently practised and the amount of nitrogen that legumes contribute to the total nitrogen requirement is not known at present.

Improved application of nutrient requirements

Farmers may receive from OMAF, at no charge, soil analyses to evaluate plant-available phosphorus, potassium, and magnesium, as well as pH. However, there is no soil test available for nitrogen under Ontario conditions. Nitrogen fertilizer recommendations are based on the region of the province, the expected yield, the crop history of the soil, and manure application.

When fertilizer costs increase more than the crop value, less fertilizer should be applied. A major reduction in current rates of fertilizer application should result in only a small decrease in yield.

The adage that 'a little more does no harm' does not apply to fertilizer. Apart from nutrient contamination of the watershed, excessive or careless fertilizer use may cause toxicity in plants. Yield-response tests have shown that corn yields actually decline with urea and anhydrous ammonia applications above 140 kg/ha.

Manure management

Improved manure storage

Nutrients are lost from manure in varying amounts according to the method of storage. Phosphorus and potassium are lost by leaching (dissolving in rain water and running off). Nitrogen is lost both by leaching and by evaporation of ammonia and gaseous nitrogen.

Quantitative nutrient losses in storage are generally poorly understood, but very high losses of nitrogen (the most valuable nutrient) seem to be common (Table 3.4). If manure storage were improved so that 20 per cent less nitrogen was lost, and assuming 0.75 per cent nitrogen for all manure, an annual saving of 27 500 tonnes of nitrogen fertilizer could be achieved, or about 20 per cent of current Ontario applications.

TABLE 3.4

Relative nutrient losses from stored manure

System	Nitrogen loss (%)
Solid	
Bedded confinement, broadcast spread	30-40
Open lot, solid spreading, liquid runoff collected and irrigated	50-60
Liquid	
Deep pit storage, broadcast spread	30-65
Anaerobic lagoon, irrigation or broadcast	60-80

NOTE: Manure applied to ground surface and incorporated immediately

SOURCE: Southwell, P.H. and T.M. Rothwell, *Report on Analysis of output/input energy ratio of food production in Ontario*. Ottawa: Agriculture Canada, March 1977.

Methods available to reduce nitrogen losses in manure include anaerobic digestion and composting. Greater detail on these methods is presented in Research Report 2.

Improved manure application

Timeliness is the critical factor in minimizing nutrient losses during application. OMAF recommends that for best plant nutrient utilization manure should be 'applied in the spring and preferably covered with soil the same day to prevent loss of ammonium nitrogen to the air. When manure is covered immediately after application it is estimated that it will provide 25 per cent more nitrogen to the crop than where it is not covered. Most of the nitrogen loss occurs in the first week after application. Unfortunately, the ideal time for manure application, a time-consuming operation, is also the busiest time for other farm tasks. Optimum application is therefore difficult to achieve in practice.

Availability of manure nitrogen

It is estimated that only 50 per cent of manure nitrogen is available to the plant in the year of application. Methods of incorporation such as injection of liquid manure can increase nitrogen availability by 18 per cent. The remaining 32 per cent is in the form of complex organic nitrogen compounds not immediately available to the plant, but which, if proper conservation is practised, become available slowly over several years.

Many organic farmers report a four- to five-year transition period from the inception of an exclusively manure nitrogen fertilization program until crop yeilds return to previous levels.

Energy replacement value of manure

The net energy reduction from the use of manure to replace nitrogen fertilizers on corn is estimated to be about 25 per cent. However, most of the energy used to apply manure would be diesel or gasoline, while most of the energy saved from not using chemical fertilizers would be natural gas.

The net energy reduction from using manure to replace chemical fertilizers on wheat has been measured to be between 15 and 58 per cent, depending on the region (Research Report 2, Appendix 6.3).

In summary, gross Ontario data suggest that legumes and manure could replace from 25 to 50 per cent of the current consumption of chemical nitrogen fertilizer. However, such a degree of replacement will not be easy to achieve in practice because of the importance of timely application and the fact that the source of manure will often be far from where it is needed for crop production.

Conclusion

Improved fertilizer management could lead to reduced energy inputs per unit of output. Fertilizer would be more effective with more careful prescription and application. In order to achieve this it is desirable that the program for soil testing be maintained and expanded. Standards of testing and fertilizer applications based on those tests should be well publicized in the farm community.

To reduce reliance on external energy inputs, it is important to investigate new crop varieties and species and new cropping practices that will lead to more efficient nitrogen enrichment through crop rotations.

Other related areas where research is recommended are erosion control to combine maximum output with minimum energy use and the integration of crop and livestock operations as a means of saving energy.

Manure management is an important aspect of livestock and crop integration. The development and dissemination of information on recommended systems should include a program of on-farm pilot project demonstrations.

TRANSPORTATION

The opportunities to improve efficiency in farm transportation seem to be limited and in many cases are already being implemented (Research Report 4).

Relative energy efficiency of transport modes

Comparing the energy efficiency of different transport modes presents difficulties because average figures vary greatly depending on the loads being carried, utilization levels (e.g. loaded miles as a proportion of total miles), the terrain and/or distances traversed, the condition of the equipment, and the speed and manner in which it is being operated. As indicated in Table 3.5 there are substantial variations in energy consumption as measured by net kilometres per litre within individual modes.

For a specific commodity movement the utilization levels and other factors may vary with each mode. For example, with most long-distance truck movements (except where specialized equipment is involved), utilization of 90 per cent and more is achieved. Rail efficiency for such movements is 50 to 60 per cent in general. Also, rail mileage is generally greater than road mileage by 15 to 20 per cent. Generally speaking rail is more fuel-efficient than trucking, but other factors besides fuel use determine the mode selected for agricultural transport.

Trucks represent the single most significant mode for agricultural transport. Not only does trucking handle the vast majority of intraprovincial movements and virtually all the traffic to and from Ontario farms but it is also a very important mode for the import sector. For example, almost all fruits and vegetables from Florida and most fruits and vegetables from California come to Ontario by truck.

TABLE 3.5

Relative energy efficiency assumptions

Vehicle (operating assumptions)	Net tonne-kms per litre
1-ton farm pickup truck	
- 1 tonne payload	
- 2.5 km/L gasoline	
- 50% utilization	1.25
2-axle straight truck	
- 6.0 tonne payload	
- 1.8 m.p.g. gasoline	
- 50% utilization	5.4
5-axle semi trailer	
- 20 tonne payload	
- 2.02 m.p.g.	
- 80% utilization	32
- 90% utilization	36
5-axle semi-trailer	
as above but refrigerated	
- 1.81 m.p.g.	
- 80% utilization	29
- 90% utilization	33
5-axle semi-trailer	
- 27 tonne payload	
- 2.02 m.p.g. (airfoil equipped)	
- 80% utilization	44
Rail car (grain)	
- 60 tonne payload	
- long-haul 59% utilization	115[a]
Rail car load service	
- 45 tonne payload	
- 60% utilization	74[b]
Trailer on flat car long haul	
- 30 tonne payload	
- 75% utilization	64[b]
Great Lakes ship	
- 50% utilization	43 - 63[c]
Ocean transport	89 - 446

a. Calculated based on data presented in 'Report of the Commission on the Costs of Transporting Grain by Rail,' Volume 1, Appendix E.

b. See David Smith (July 1980) 'Ontario Task Force on Provincial Rail Policy,' Table 16.

c. Committee estimate assuming 250 kilometres a day on average within the Great Lakes, allowing for delays at locks etc. and considering variety of ship types.

The significance of energy as a truck transport expense varies greatly with the type of truck, the annual mileage, and the average length of haul. Short-distance trips within built-up areas have high labour costs per kilometre, with labour accounting for well over half of total operating expenses. As trip lengths increase, per-kilometre pickup and delivery costs decline, and the significance of fuel cost as a proportion of total costs increases. For example, the 1978 estimated cost per kilometre for a five-axle semi-trailer operating in Ontario, assuming 300 kilometre round trips and 160 000 km/yr, is $0.78/km, with energy accounting for 14.7 per cent of this total. Assuming that the same unit is running round trips of 2500 km, the cost is estimated to decline to $0.68/km, with energy rising to 16.7 per cent of total operating costs (Research Report 4).[1]

In order to assess the implications of expected energy price increases for agricultural transport, energy costs in 1985 and 2000 for different truck trip lengths and equipment types have been estimated, along with total transportation costs, assuming that no technological or regulatory changes occur over the forecast periods (Table 3.6).

The forecast energy cost increases (all expressed in constant dollars) translate into significant out-of-pocket cost increases for farm operators. For the farm pickup truck, it is estimated that the projected gasoline price increases alone will lead to an 11 per cent transport cost increase during 1978-85 and an 18 per cent cost increase from 1978 to 2000.

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[1] These estimates are based on 'Operating Costs of Truckers in Canada 1978' Trimac, 1978. Some of the original cost and price assumptions provided in this source were modified by the author.

TABLE 3.6

Energy as a cost in agricultural trucking (percentages)

	1978	1985		2000	
Trip length (truck type)	Energy costs/ Total costs	Energy costs/ Total costs	Impact of energy price increases on costs 1978-85	Energy costs/ Total costs	Impact of energy price increases on Costs 1978-2000
Short-distance movements between farm, processors, and markets (15 and 3 miles one way)					
- Farm pickup truck	28	35	+11.2	39	+18.4
- Two-axle straight truck, farmer operated	23	29	+ 9	33	+11
- Two-axle straight truck (for-hire)	11	14.6	+ 4.3	16.8	+7
Medium-distance movements intra-provincial, inter-provincial, inter-national (100 miles 1 way, for hire)					
- Two-axle straight truck	15	19	+ 6	22	+ 9
- Five-axle semi-trailer	15	20	+ 7	22	+11
Long-distance movements (750+ miles one way, for hire)					
- Five-axle semi-trailer (Can)	17	23	+ 8	26	+12.0
- Five-axle semi-trailer (USA)	15	26	+15	29	+20

NOTE: Transport cost increases in constant $1980 assuming no technological or regulatory changes

For a two-axle straight truck operated for-hire, total operating costs are estimated to increase only 4.3 per cent because of energy prices during 1978-85 and 7 per cent from 1978 to 2000.

The transport cost increases estimated for medium- and long-distance movements are of greater significance. For a five-axle semi-trailer operating over medium to long distances within Ontario, the projected fuel price increases could lead to an 8 per cent increase in transportation and operating costs during 1978-85 and a 12 per cent increase from 1978 to 2000. The corresponding increases in U.S. trucking rates are 15 per cent during 1978-85 and 20 per cent from 1978 to 2000, the larger increase being due to more rapid energy price increases in the United States.

In assessing the implications of fuel price increases on trucking costs and freight rates one must consider technology, regulation, utilization levels, and the relationship between the costs and rates. For long-distance trucking at least, it appears that trucking costs and rates are closely related on average over the year. Comparison of estimated trucking costs (allowing for 10 per cent profit) and published trucking rates suggests that the present long-distance truck transport costs are competitively determined. Therefore the projected fuel price increases can be expected to lead to rate increases and/or to stimulate a variety of efforts to achieve fuel savings and other cost economies in truck transport.

A wide variety of technological and operational changes to increase the fuel efficiency of the truck mode are being implemented by the industry and will at least dampen the effects of fuel price increases on total costs and on freight rates.

The opportunities for improvement are greatest for intercity truck operations, and the results reported to date are impressive. Some truck operators claim to have increased fuel economy by 2 to 3.5 km/L for line haul semi-trailers. Such fuel efficiency improvements, if confirmed, would more than compensate for the projected fuel increases assumed in this report, and would enable Canadian and U.S. truckers to maintain rates at constant levels (in 1980 dollars).

The above analysis indicates that while rising energy prices will have a significant effect on long-distance trucking (particularly on the movement of fruit and vegetables from the United States) it appears that energy conservation initiatives such as those listed in Appendix M will reduce the impact below the levels estimated in Table 3.6. Note that, in the short term, interest rate increases are of greater concern to truckers than fuel prices (from December 1979 to 1980 depreciation and interest costs rose 2 1/2 times as fast as fuel costs; U.S.D.A., Fruit and Vegetable Cost Report).

Energy price increases are likely to affect rail and marine transport rates as well, though probably not enough to create import substitution opportunities. These modes are competing for traffic, as shown by the switch from truck to rail of the transport of live western cattle to Ontario.

Overall, transport cost increases generated by higher energy prices are not expected to generate significant opportunities for import replacement in Ontario. In fact, the significant energy efficiency improvements already being implemented in transportation will tend to reduce the opportunities for import substitution arising from price differentials between imports and Ontario-produced food.

Institutional factors and utilization of vehicles

It is not at all clear that changes in the PCV Act will improve utilization levels significantly in Ontario. Short- and medium-distance movements to and from Ontario farms have low backhaul potential, and unless farmers are prepared to wait much longer than they do now for pickups and deliveries, this situation will not be substantially improved by regulatory changes (Research Report 4).

Overall truck utilization is high, and the effect of PCV regulations on utilization appears to be small. Where PCV regulations have the greatest potential impact on agriculture (as in the shipment of cattle from Ontario farms to sales barns and the movement of produce from Ontario farms), they tend to be ignored. However, this is not to say that increased efficiency is not possible and that the restrictions placed on PCV licences should not be relaxed or the regulations themselves modified.

Trip-leasing, an item discussed at length by the Select Committee on Highway Transportation of Goods and recommended by Biggs (E. Biggs Associates, Report to the Ontario Government on the Review of Farm-Related Trucking, January 1980), may improve utilization and deserves further study. The Ontario Trucking Association has serious concerns about the administration of such a system and the potential for abuse, but it may be the only way to make Ontario truckers competitive again in the transport of fresh fruits and vegetables from the United States.

The Ontario Milk Marketing Board and the Ontario Pork Producers Marketing Board have rationalized the transport of specific agricultural commodities and improved the utilization of transportation services and energy. Other marketing boards may well be able to emulate them or at least encourage transport efficiencies by collecting and disseminating facts on transport patterns and costs and by researching the costs of changes in methods of operation (e.g. buying closer to market so as to reduce cross-hauling or instituting co-ordinated pickup and delivery).

Conclusion

Although energy costs will increase as a proportion of total transport costs, the rise will be tempered by substitution and conservation, with the pickup truck being most affected and the medium-distance truck least affected. Available evidence suggests that agricultural trucking operates at high rates of utilization, encouraged by Ontario load limit regulations. The economics of long-distance trucking make it absolutely necessary to have a return load if at all possible, especially where trucks are in competition with rail. Trips will not be made where effective competition exists, unless the trucker has a return load.

For short- and medium-distance shipments, such as from farm to processor or supplier to farm, the opportunity for backhauls is much smaller, and this fact is built into trucking rates. For all trips of less than fifty miles on Ontario highways in 1978, one-third of truck movements were empty (MTC Survey of Trucking on Ontario Highways, 1978). The situation is probably even worse than that for short- and medium-distance trucking to and from Ontario farms. The best potential for savings in this type of movement would appear to be with products sold through marketing boards and collected at the farm gate or at a central delivery point so that transport can be centrally controlled as part of the marketing function. The movements of milk and pork have been rationalized in this way; other possibilities are wheat, white beans, and eggs.

The Committee supports existing programs to encourage transport efficiency by means of technical improvements such as fan clutches and air foils as well as ongoing efforts to remove regulations that discourage efficiency.

Trip-leasing deserves further study. As noted by the Ontario Trucking Association in 1977, non-PCV carriers are using variations on the trip-leasing proposal at this moment (for the transport of U.S. fruit and vegetables to Canada).

Substitution for oil in off-farm transportation has limited potential. Larger trucks cannot be effectively changed to propane fuel, and the only opportunity is for the smaller vehicles, mainly pickup trucks.

The very scarce specific data available on feed mill operations indicates a substantial potential for both energy efficiency improvement and substitution of oil. Energy efficiency in one case study was improved more than 9 per cent in dollar terms, and most investments to achieve these savings had a payback of three years or less, with the longest payback being seven years.

Many feed mills use furnace oil for raising steam in their boilers, and natural gas could be substituted.

Neither efficiency nor substitution in feed mill operations requires a new or separate program or even special action. This group should simply be included in the industrial energy conservation programs for the food and beverage industries.

GREENHOUSES

Energy consumption

The energy consumption of a greenhouse is determined by the temperature differential between inside and outside as well as by the combined thermal resistance factor of the glazing material and exposed structural members. A wide range of cases must be considered (Research Report 3). Since most greenhouses (67 per cent) are still covered with glass, a glass greenhouse is considered as the reference point. The calculated fuel consumption on a square-metre basis is given in Table 3.7.

Table 3.7 shows that the fuel consumption in the two areas of greatest greenhouse concentration (Windsor and Vineland) is about the same. Actual fuel consumption for greenhouse operations located in these areas has been documented to be within 10 per cent of these values.

Year-round operation of greenhouses is a common practice for most flower growers (pot and cutflower production). Vegetable growers (tomatoes and cucumbers) as well as bedding plant growers often use their greenhouses during only part of the heating season. A greenhouse in year-round operation will use 60 per cent of its normal heat load during December, January, and February.

Another major heat-demanding component of greenhouse operation has been the practice of soil pasteurization, which appears to be the only reliable way to destroy any parasitic organisms present in the growing medium. The amount of energy needed for a thorough pasteurization is about 225 MJ/m^3 of dry soil (Towning and Turkewitsch 1980) or 440 MJ/m^2 of greenhouse floor area with moist soil (Poole and Badger 1980). Both values refer to pasteurization procedures where the soil temperature is raised and kept at 90°C for about twenty minutes. It is not unusual to use 15-20 per cent of the total annual fuel consumption for pasteurization.

TABLE 3.7

Annual heat demand (MJ/m/^{2}) and fuel consumption for a gutter-connected glass greenhouse maintaining 18° C (night) and 20°C (day)

Location	Annual heat demand MJ/m^2	Natural gas consumption m^3/m^2	No. 2 oil consumption in litres/m^2	(gallons/sq. ft)
Toronto	2600	90	85	(1.7)
Ottawa	3200	105	100	(2.1)
Windsor	2600	90	85	(1.7)
Vineland	2700	90	85	(1.7)
London	3000	100	95	(1.9)

Mechanization in the greenhouse industry has led to substantial electrical consumption. Electrical motors used for the boiler, storage area, irrigation, and ventilation, photoperiodic lighting, and other electrical equipment are part of this development. An annual consumption of 15-20 kWh per square metre is a general average for a conventional operation with forced-air heating. The latter covers about 30-50 per cent of the total greenhouse area. This consumption rate does not apply to growers who use supplementary lighting in the majority of their greenhouses. Supplementary lighting at an installed capacity of 50-80 W/m^2 and operating 2000 hours a year creates an additional electrical consumption of 100-160 kWh/m^2/year.

Energy conservation in existing greenhouses

The consumption of liquid fuel in greenhouses is a function of three main factors and can be described as follows:

fuel consumption = overall thermal conductance X temperature differential X fuel conversion efficiency.

Techniques influencing these three factors will be discussed separately.

Thermal conductance

The thermal conductance of the greenhouse structure can be reduced by changing from single to double glazing. The application of air-inflated double polyethylene is the most widely accepted technique. The overall fuel saving of a double polyethylene greenhouse compared to a single-glass greenhouse depends on the type of heating system and the growing techniques used. In general, savings of 20-40 per cent are obtained. The use of double-layered rigid materials (e.g. SDP) has not been rapidly accepted because of the relatively high material and affiliated building costs, as well as the potential danger of collapse under an excessive snow load.

Additional retractable or non-retractable thermal barriers to prevent heat losses through the roof have been used. The retractable screen is positioned between the crop and the glazing material; it is drawn over the crop at night and pulled back during the daytime. Retractable screens can save 10 to 33 per cent of the heat lost annually.

However, the economics of retractable screens for heat retention are questionable, especially on a short-term basis (less than five years) at today's fuel prices and with reduced yields caused by thermal blankets. Moreover, the installation costs for such a system have been excessive for free-standing greenhouses or in the older types where supporting posts are obstacles for a movable thermal screen system.

The most effective non-retractable heat retention system has been the use of double polyethylene over glass. This application has been useful in older and leaky houses and where crops not needing high light levels (bedding plants, poinsettias, and foliage plants) are being grown. Energy savings of up to 55 per cent have been reported.

Another technique has been the use of an inflated air blanket beneath the greenhouse roof. The energy savings of 35 per cent are lower with this technique than with double polyethylene over glass.

A single layer of polyethylene placed on top of the glass greenhouse or just under the greenhouse roof has also been a low-cost energy conservation practice. The plastic is often used only for one heating season and removed during the spring. Energy savings are from 10 to 15 per cent.

A more permanent technique is the injection of a silicone paste between the glass laps as a seal against cold air infiltration. A well-maintained greenhouse has a natural air exchange (apart from ventilation) of 1.0-1.5 air volumes an hour. The actual energy savings of sealing the glass are from 5 to 20 per cent. A major disadvantage has been a buildup of humidity and the constant water condensate dripping from the sealed glass laps onto the crops.

Although heat losses through sidewalls may contribute only 25-30 per cent of the total heat losses, conservation techniques have been concentrated in this area. Different reasons can be given for this. First, the sidewalls can be easily insulated by the grower himself with such materials as an additional single layer of plastic, polystyrene, aluminum, or silicone between the glass laps or even the installation of a double-layered material. Secondly, the insulation of sidewalls prevents cold areas and results in more even production. Thirdly, sidewall insulation does not affect the light intensity or the relative humidity as much as overhead insulation. Another way of reducing the heat losses is by placing a windbreak around the greenhouse.

Temperature differential

Reducing the temperature difference between inside and outside the greenhouse can be achieved in several different ways.

First, the greenhouse can be kept empty during the winter. Vegetable and bedding plant growers for instance can transplant at a later date.

The conventional practice has been to maintain a constant minimum temperature at night. New evidence has shown that various crops only need the minimum temperature for four or five hours each night, after which the temperature can be dropped by 3 to 8° for the remainder of the night without delaying or affecting the crop extensively. The energy saved by splitting the night temperature in the way is about 5 to 15 per cent.

Many crops require less than the average amount of heat (lettuce, carnations, cyclamen, cineraria, fressias, etc.). However, these crops have limited market potential. Growing crops at a cooler temperature in combination with soil heating also is a relatively new concept, though it can be done with only a few special crops and the installation cost of soil heating equipment can be substantial.

Fuel conversion efficiency

The conversion of fuel into heat is conventionally achieved by means of boilers or unit heaters, where the heat of combustion is converted into hot water or steam or directly exchanged with the greenhouse air. The overall seasonal efficiency of either system tends to be 70 to 80 per cent. In other words, at least 20 per cent of the heat is lost during combustion. The major heat loss is accounted for by the combustion efficiency of the boiler or heat unit. Higher combustion efficiency can be obtained by means of retarders and/or economizers, depending on the type of boiler and the fuel used.

Recently a new heating technique has been introduced to the greenhouse industry, namely the use of low-intensity infrared heat. This technique is very efficient and has the added advantage that the air temperature in the greenhouse can be maintained 1 to 3°C lower than the conventional system. Research in this field is still in its infancy, but initial results look promising. The energy-saving potential of this technique is 5 to 45 per cent for a short crop with a moderate heat demand. Application of this technique to tall crops with high heat demand may be limited.

Energy conservation techniques and technology

At present there are many more techniques available to reduce the fuel consumption for a particular operation than those discussed above. There are two approaches to reduce the relative fuel costs: reduction of total fuel consumption per greenhouse range as discussed above; and reduction of fuel consumption per unit product. The latter can be achieved by either improving the growth rate of the plant or by making better use of the greenhouse space. A list of techniques is given in Table 3.8.

Many techniques have already been implemented, especially by flower growers who have been able to use many of the examples shown in the last section of Table 3.8. The techniques listed in the first three sections apply to both vegetable and flower growers. Although it may appear that all techniques, if applied, would reduce the energy consumption by nearly 100 per cent, they cannot all be applied to every greenhouse range or to every crop. An estimate for the reduction of fuel consumption from each of the individual factors for the total industry is given in Table 3.9.

TABLE 3.8

Energy conservation techniques and technology for greenhouses

	Technique	Range of energy savings (%)
	Reduced thermal conductance	
1	Double glass (roof glazing)	20 - 40
2	Double polyethylene (roof glazing)	20 - 40
3	Thermal pane	10 - 20
4	Double layered acrylic (roof glazing)	20 - 40
5	Double-layered polycarbonate	20 - 45
6	Double polyethylene over glass	30 - 60
7	Single polyethylene over glass	15 - 20
8	Single polyethylene under glass	10 - 15
9	Air blanket (double polyethylene under glass)	20 - 35
10	Air tubes (deflatable air blankets)	15 - 30
11	Lapseal	5 - 20
12	Bar capping & general maintenance	5 - 10
13	External windbreaks	5 - 10
14	Cable wall insulation	1 - 4
15	Sidewall insulation - styrofoam	2 - 6
	- double glazing	5 - 10
16	Insulation of perimeter footings	2 - 4
17	Thermal blankets	10 - 35
	Reduced thermal differential	
1	Reduced air temperature	5 - 25
2	Split night temperature	5 - 15
3	Soil warming in combination with reduced air temperature	1 - 5
4	Altered planting date	5 - 60
5	Infrared heating	5 - 45
6	Correct heating pipe placement	2 - 5
7	Uniformity of air temperatures maintained	5 - 10
8	Precise control of temperature	1 - 5
9	Alternative cool crops	10 - 40
10	Changed varieties	2 - 10
	Optimized fuel conversion	
1	Efficient boilers	5 - 25
2	Recaptured stack losses	2 - 10
3	Use of economizers	5 - 15
4	Use of retarders	2 - 7
5	Preheat water boiler	2 - 5
6	Insulated boilers	2 - 5
7	Insulated boiler room	1 - 5
8	Back draught louvre on stacks	2 - 10
9	Duty cycling of boilers	1 - 5
10	Correct placement of unit heaters	2 - 4
11	Hot water instead of steam	5 - 15
12	Insulation transmission mains	1 - 5
13	Repaired leads in traps, etc.	1 - 5
14	Heat exchanger pipes painted black	1 - 4
15	Modulated burners	2 - 5
16	Efficient electric motors	1 - 10

TABLE 3.8 (cont'd.)

	Reducing the fuel input per unit product	
1	Movable benches	15 - 30
2	CO_2 utilization	5 - 10
3	Soilless production systems	0 - 20
4	Multiple level shelving	20 - 50
5	Smaller unit size	5 - 40
6	Chemical sterilization or use of aerated steam for disinfecting the soil	5 - 20
7	Production of prefinished crops	10 - 50
8	Adoption of varieties with shorter growing time	5 - 20

NOTE: The energy savings are for a glass greenhouse where no energy efficiency techniques have been applied.

TABLE 3.9

Estimate of reduction in fuel consumption for the greenhouse industry

Component	Reduction (%)
Overall thermal conductivity	30
Temperature differential	10
Fuel conversion efficiency	20

Using the formula at the beginning of this section, the energy consumption can be reduced by (0.70 x 0.90 x 0.80) or 50 per cent.

It should be remembered that the economics of the described techniques have not been considered for this exercise. The cost effectiveness of some of the described techniques are compared in Research Report 3.

Waste heat management and greenhouse production

The Ontario greenhouse industry provides 5000 jobs and generates annual sales of about $115 million. 45 per cent of Ontario greenhouses are fuelled by natural gas with oil as the backup fuel. The other 55 per cent are fuelled by oil and propane. The cost of fuel is at present about six times as great as the cost of fuel required to transport competing crops from Mexico, where land and labour costs are lower. However, even the availability of cheap waste heat will not be sufficient to ensure the survival of a greenhouse industry. Growers must be able to earn at least as much in greenhouse production as in other activities or the industry will not survive.

It was concluded that the greenhouse vegetable industry will have major difficulties adjusting to higher fuel costs if steps are not taken. Rapid increases in fuel costs, rising land values, rising equipment costs, and unstable market conditions have led to an unstable greenhouse industry for the production of vegetables. Producers of flowers have managed to stabilize their output and price levels and are making a satisfactory return. However, any steps taken to assist the industry should not discriminate against flower growers.

The Committee concluded also that the conditions of survival of the greenhouse vegetable industry are stabilized markets, assistance to improve the heat efficiency of the existing stock of structures, and assistance to growers to attract them to areas where waste heat is available on a reliable basis. However the Committee recognizes that even if assisted to move to waste heat areas, the greenhouse industry may, because of the rapid increase in other costs, remain marginal. A variety of other factors make growers resistant to relocation. These include availability of local markets, a substantial investment sunk in plant and equipment, and the social cohesion of communities in which greenhouse horticulture is a tradition. Before growers will move they must be convinced that to do so will yield substantial and long-term benefits to both individual growers and the industry as a whole. They need more detailed information about waste-heat sites, including climate, sites, engineering, and distance from sites to the heat sources and to eventual markets.

Steps must be taken to make vegetable production from greenhouses more reliable economically. The steps should include protection from dumping of cheap vegetables, tariff protection where necessary, the development of long-term marketing arrangements with chain stores, assistance with the design of low-energy, low-labour greenhouses to reduce costs, assistance to improve product quality, and assistance to promote Ontario-grown greenhouse produce. Greenhouse vegetable growers have made marginal profits since 1973 but have remained in business because of land appreciation and a willingness to work for a low return on both labour and invested capital. A detailed review of the long-term viability of greenhouse production should be undertaken, taking into account new sources of domestic and international competition and assessing with care the costs and benefits of long-term investment in the industry in Ontario.

The Committee reviewed the position of greenhouse growers in the flower business. $96 million worth of flowers were sold last year, and the industry is profitable, since cost increases can be passed on to the consumer. About 16 per cent of the industry can switch immediately from vegetables to flowers, depending on the market, but virtually any greenhouse can switch from vegetables to flowers in about three months. Any assistance to flower growers could lead to a major switch from vegetables to flowers, and public grants to flower producers could lead to dumping charges from American growers. It was concluded, therefore, that growers who receive assistance to upgrade greenhouses or to move to waste heat sources should be required to remain in vegetable production for an agreed period. Once the transitional period has passed, the policy of non-discrimination between vegetable and flower growers should be reinstated.

Conclusion

Numerous ways to reduce the energy consumption in the greenhouse sector have been considered. They can be divided into three groups: improving the overall thermal insulation of the greenhouse, reducing the greenhouse temperature, and optimizing fuel conversion into usable heat.

Each technique has to be considered on its own merits for any operation, taking into account the crops grown, greenhouse types, heating systems, and so on. Although it would be difficult to achieve, the total fuel consumption for the total industry could be reduced an estimated 50 per cent. The largest portion of the fuel saving can be obtained by increasing the overall thermal insulation of the greenhouse.

Solar energy, coal, municipal waste, and geothermal energy have been considered as alternative heat resources for the greenhouse industry. None of them appears very promising within the near future (ten to fifteen years). The use of reject (waste) heat from industrial plants appears to be the best alternative in the short term.

Several barriers to energy conservation have been identified. At today's fuel prices the high production costs entailed by many of the available technologies seem to be most important barrier to their implementation. For vegetable operations, the main economic barriers are the high investment costs compared to gross revenue, the smaller fuel consumption than that of flower growers (because the greenhouse is not used in the coldest season), and the insecurity of the price of the product. Flower growers have additional options not available to the vegetable grower to reduce the energy input per unit of product by using different management techniques (movable benches, closer spacing, hanging baskets, etc.).

Greenhouse floriculture is still growing in Ontario, but vegetable greenhouse production is not. Immediate implementation of energy conservation technology will require incentives of various kinds, such as tax relief, low-interest loans, or grants to reduce predicted payback periods for the capital-intensive energy-efficient technology.

As reject heat utilization becomes a technological reality, the orderly transition of greenhouse area to suitable sites should be supported with relocation incentives.

Direct market control is not desired by most of the industry. Instead an increased promotional program to expand the domestic and export market for Ontario greenhouse production would be preferred. Market development should be in conjunction with programs already initiated by government and greenhouse organizations.

The government should continue to expand the functions of research and education in the area of energy conservation, alternative energy development, and greenhouse crop production.

FUEL SUBSTITUTION

About 68 per cent of all direct on-farm energy use (about 20.9 PJ) is based on petroleum fuels, mainly gasoline, diesel, fuel oil, and propane. About 25 per cent of this amount is propane (including propane derived from natural gas), leaving a real substitution potential of 15.7 PJ, the equivalent of 410 000 cubic metres (2.58 million bbls) of oil. Much of that potential consists of fuels used in mobile applications such as farm machinery and pickup trucks and so in the short run at least is difficult to replace. However, a substantial portion is used in stationary applications and can more easily be replaced with substitute fuels. Figure 3.1 shows the average on-farm use, and thus the potential average replacement, of gasoline (mobile uses), heating oil (stationary uses), and propane on farms. For most farm types except poultry raising, much more gasoline is used than heating oil. Overall, the replacement potential for stationary fuels is probably about 4.96 PJ, or about 158 900 cubic metres (1.0 million bbls) of oil annually.

A wide range of substitution possibilities are considered in the following sections, including propane, natural gas, alcohol produced on the farm, vegetable oils, and renewable energy sources such as solar and wind.

NON-FARM ENERGY SUPPLIES

Propane

Propane is an immediately available substitute fuel within the farm sector (Research Reports 2 and 5). Derived mainly from natural gas, it is readily transportable by both pipeline and truck, and can therefore be made available to most farm locations. Propane is already used on many farms for special purposes.

At current prices the market for propane is considered to be substantially penetrated. Table 3.10 compares the price of propane on an energy-content basis with those of its two main competitors, natural gas and fuel oil. While propane is more expensive than the other two fuels, it competes directly only with fuel oil province-wide because natural gas is restricted to farms located near the distribution network.

Figure 3.1 Average annual on-farm use of gasoline, heating oil, and propane (GJ)

Source: Research Report 2

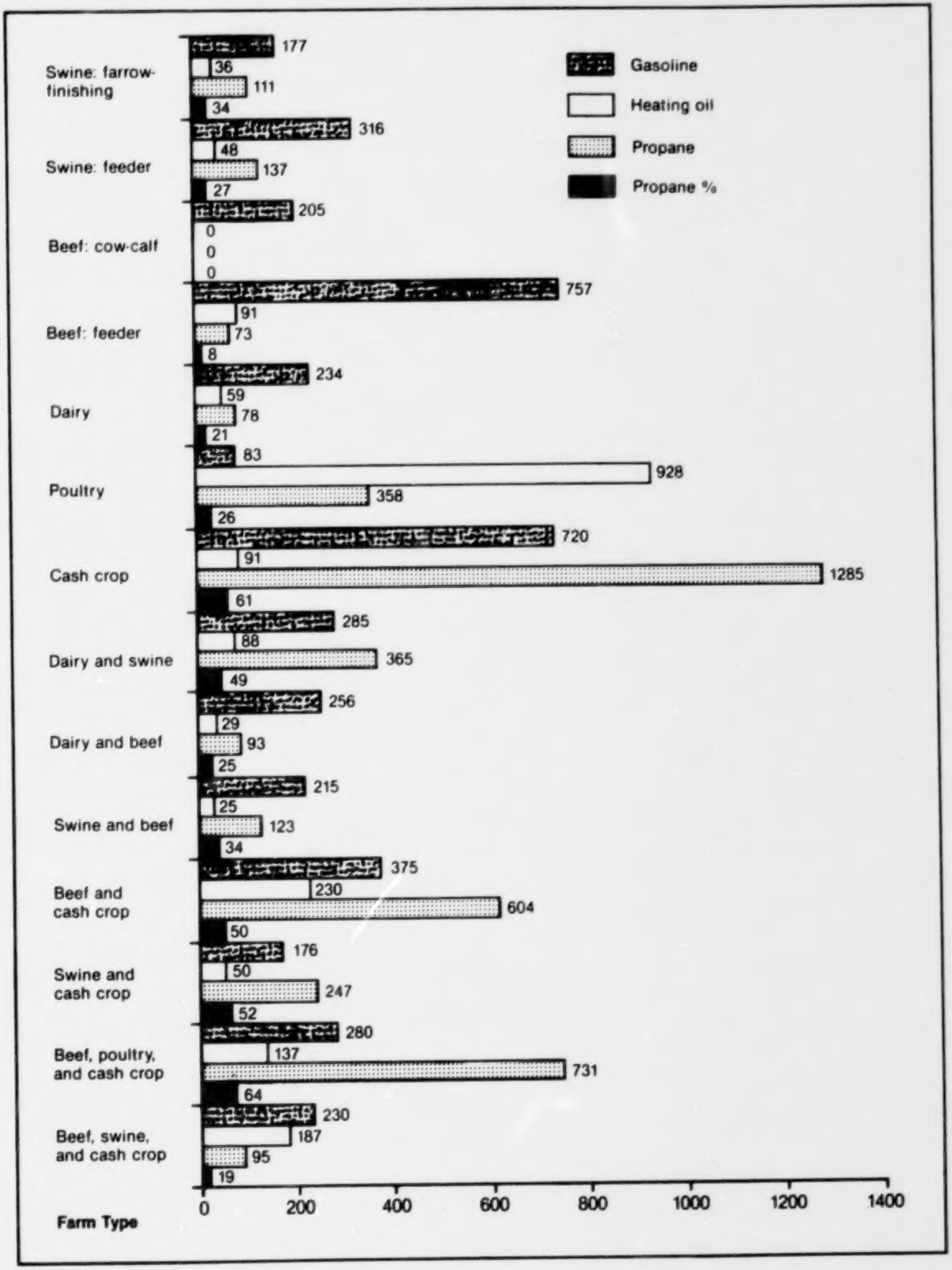


TABLE 3.10

Comparative Ontario energy prices

Energy source	Cost per GJ October 1980 ($)
Propane	8.90
Fuel Oil - No. 2	7.00
Natural gas	4.16

Ontario farms use an estimated 109 million litres (24 million gallons) of propane a year. Depending on the type of farm, propane's share is as high as 64 per cent of total substitutable fuel. Overall, propane usage is about 33 per cent of total substitutable fuel on farms. Hence, about one-third of the possible fuel substitution has taken place already; the other two-thirds is composed of fuel oil and gasoline that could be displaced by either diesel fuel or propane.

Propane would most readily replace fuel oil because both are used at present in stationary applications. The gasoline would be replaced by alternative transportation fuels, one of which is propane.

Propane substitution in stationary uses. The cost of conversion from oil to propane for stationary uses on the farm depends upon the equipment to be converted and the cost of propane storage and connection facilities. This conversion would include the replacement of an oil burner with one designed for propane and possibly some other changes that would vary with the equipment in place. Sometimes a complete replacement of old or worn equipment or appliances may be necessary.

The cost of a propane storage tank and a connecting system ranges from about $900 for a small installation to $6000 for a 4000 litre propane tank with filling attachments. The estimated cost of converting an oil-fired furnace and a hot water heater to propane is about $1000. A conversion incentive of $800 to offset some of these costs is provided for in the federal Off-Oil Program.

The optimum propane supply and distribution system on the farm consists of one large propane storage tank with a plastic pipe distribution system from the central tank to all farm propane equipment. The propane tank would also have filling attachments so that farm trucks, tractors, and mobile propane tanks on wheels can be replenished at this central storage.

To provide a five-year payback on propane conversion in stationary uses at current light fuel oil prices of about 24¢/L would require a propane price reduction of about 15¢/L, or about 20 per cent below the current price of propane. Figure 3.2 compares the payback periods for the cost of converting from light fuel oil to propane at different price differentials.

To install a 4000 litre tank and equip it in accordance with existing regulatory requirements at present costs about $6000. If these regulations were altered for agricultural applications the cost could be reduced to approximately $4000. Furthermore, although plastic pipe is acceptable for propane distribution on the farm, individual permission is required to install and operate a plastic system. The applications, amendments, and regulatory requirements are such that neither the propane distribution companies nor farm operators have the time to process the necessary applications. As a result, individual propane tanks with the standard connecting system are installed adjacent to each piece of equipment.

Propane substitution in mobile applications. The cost of conversion of gasoline-powered trucks and tractors is in the range of $1200 to $2000 per vehicle. To offset these costs there is a $400 federal incentive plus a provincial sales tax exemption on new vehicles equipped for propane use.

To calculate the payback for propane conversions in vehicles, a carburetor conversion cost of $1500 and annual fuel consumption of 2000 gallons (9092 litres) of gasoline or propane were assumed. For new vehicles that are propane-equipped the propane price could be higher because of an additional sales tax exemption.

Figure 3.3 shows how long it would take to pay back the cost of converting from gasoline to propane at different fuel prices. At current gasoline prices of about 33¢/L, propane would have to cost 7 per cent less than gasoline (30.6¢/L) to achieve a five-year payback, but 37 per cent less than gasoline (21¢/L) to achieve a two-year payback.

Figure 3.2 Payback periods for the cost of conversion from light fuel oil to propane

Source: Research Report 5

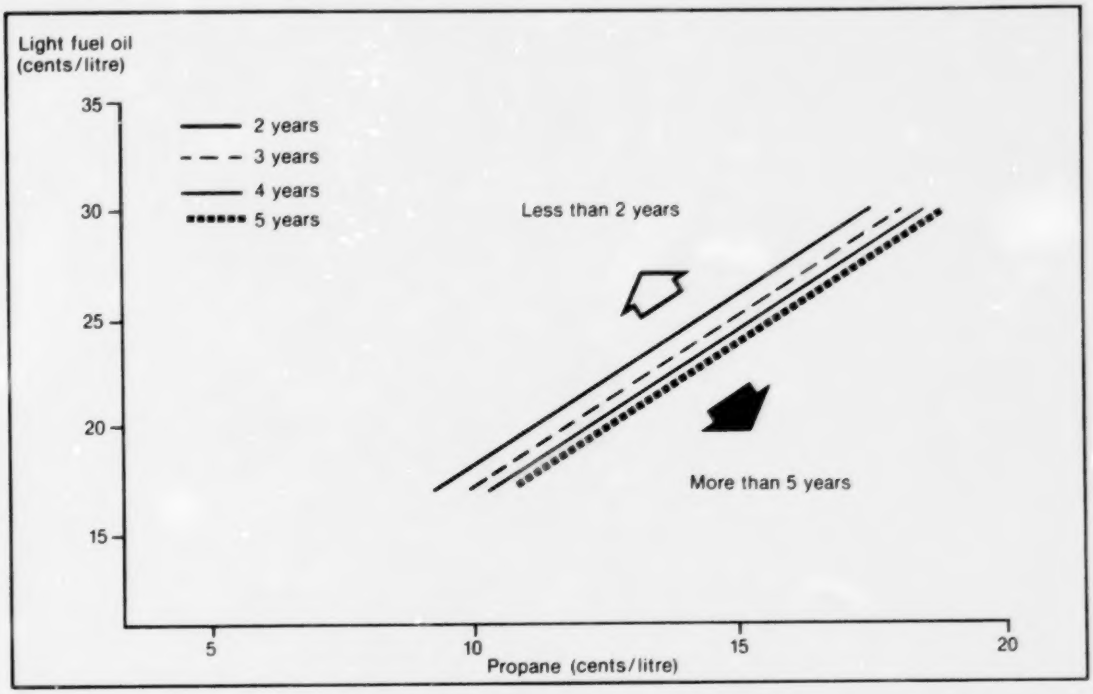
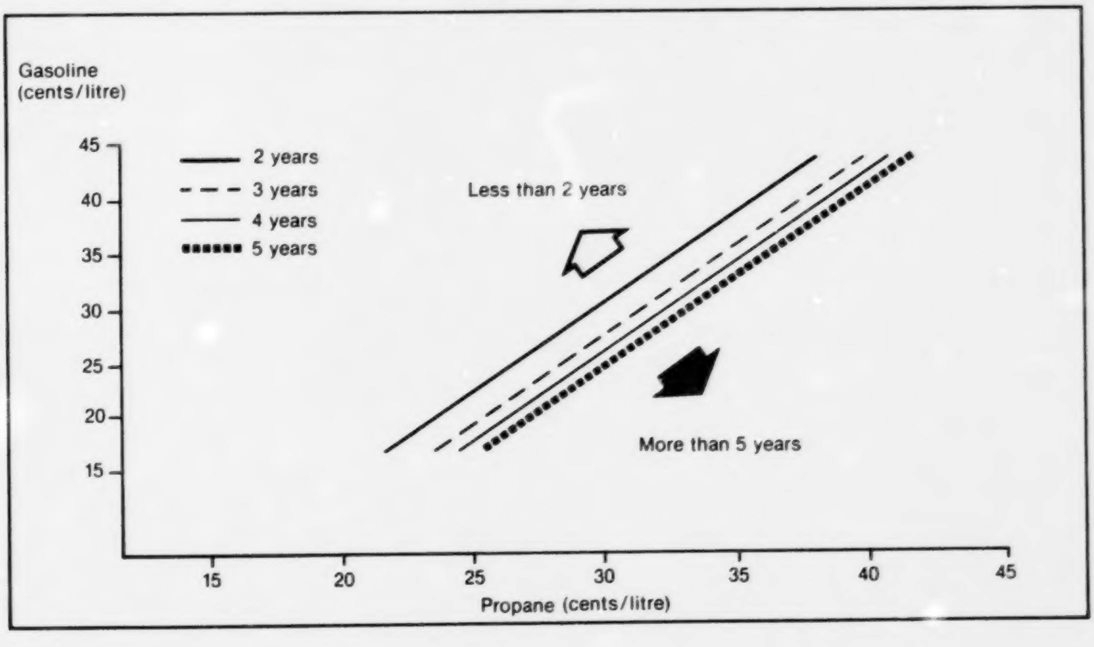


Figure 3.3 Payback periods for the cost of conversion from gasoline to propane

Note: Includes fuel tax remission but not sales tax rebate of 7 per cent

Source: Research Report 5
Source: Canadian Resourcecon Ltd. Economics of Synthetic Liquid Fuels in Ontario Road Transportation. Ontario Ministry of Energy



Natural gas

The use of natural gas on farms largely depends on the farms' being near natural gas distribution systems built for other purposes. Hence there will not be many new natural gas connections in the agricultural sector and then only to farms within an economic distance of connections to trunk or lateral pipelines between urban areas in Ontario.

Electricity

In the short term electricity will cost more than the energy equivalent in liquid petroleum fuels, so that substitution opportunities will be limited. Even in the long run electricity substitution will be limited by its applications. Electrically driven vehicles and equipment will probably not come into farm use in the next twenty years, and in some stationary applications such as crop drying electricity would be less appropriate than other options. However, up to the year 2000 electricity prices are forecast to hold constant at 1980 levels while propane, fuel oil, and natural gas prices are expected to double. After 1990, therefore, electricity will become competitive with fuel oil and propane in stationary applications, probably in space heating and cooling for animals. Poultry operations, which now require large amounts of propane and heating oil, would be a likely target group for electricity substitution in the 1990s.

On-farm energy production

Any energy produced by the farmer and used on the farm will replace conventional energy and sometimes petroleum fuels in particular. How much energy agriculture could produce for itself has never been precisely estimated for an area as large and complex as Ontario. Renewable energy technologies are still at the laboratory, in the household, or in industry. Farm-sized energy projects are rare and often in agricultural and climatic environments different from Ontario. Translation of these experiences to the Ontario farm requires the scale of operation to be adjusted upwards or downwards accordingly. For example, there are still no farm-scale ethanol plants in Canada, and very little data on them have been gathered from the United States. Most of the cost estimates are derived from the industrial operations of American plants designed to produce large volumes of corn-derived alcohol for the lucrative gasohol market (Research Report 8).

Any farm energy production should be based on a systems approach, recycling nutrients, balancing material flows, and accounting accurately for energy needs and outputs. These demands will favour the diversified mixed-crop-and-livestock farmer who is able to produce and process his own inputs of feed and fertilizer.

On-farm energy production systems such as anaerobic digestion may be primarily ways of enhancing the feed or plant nutrient value of a material, with energy being a secondary by-product.

The technological and economic feasibility of applying new energy technologies will vary with the farm. It will demand innovativeness of the farm operator, managerial skill, and the ability to comprehend, construct, maintain, and operate equipment and processes that are supplementary to the already complex task of farming. The scale of operation may also be an important factor in determining feasibility: is manure production great enough to justify anaerobic digestion? is corn production small enough to be handled by a combination of solar and low-temperature drying? Table 3.11 summarizes a number of important factors for types of on-farm energy production.

Ethanol

The costs of on-farm ethanol production will remain speculative until the results of farm-scale operating experience are known. Technically a farrow-to-finish hog farm (1770 hogs/yr) could meet its gasoline needs (5600 L/yr) from about 5.3 hectares of grain dedicated to ethanol feedstock production and 1.25 hectares of straw production for process heat. The stillage by-product (454kgs) would supply 5 per cent of the protein requirement for the herd if available throughout the year. A typical swine herd could consume all the stillage of an ethanol plant this size.

Oilseeds

Yields of 750L/ha of rapeseed oil as a diesel substitute are possible with simple extrusion methods. A doubling in yield is possible with new winter varieties. Rapeseed should be able to tolerate northern Ontario growing conditions. At present, the feedstock cost of rapeseed at market price is 73¢/L, or more than twice the current cost of diesel fuel.

TABLE 3.11

On-farm energy production, selected parameters

Energy source	Resources required per GJ produced	Unit Price	Cost per GJ
Solar	$0.43-0.87 m^2$/yr	$0.175-4.3m²	$19-237 (capital cost)
Biogas	37 hogs/day 29 diary cows/day	$40-120/hog $200-300 cow	$17-85
Direct Combustion	4-16m² grain straw 4m² corn stover 20-81m² natural woodlot	$44,000	$9.50 (Peill)
Gasification	12-16m² grain straw	$48,000-120,000	$1-68
Pyrolysis	4m² corn stover 162m² straw		cf. gasification
Oilseed	12m² rapeseed		$20.00
Ethanol	16-32m² grain 8m² corn 4m² potatoes	$10,000-80,000	$22 (Hayes)

NOTE: January 1981 cost of light fuel oil is about $8.50/GJ in Canada.

SOURCE: R.D. Hayes, 'Agricultural resources for ethanol production.' Canadian Natural Power Alcohol Corporation, Winnipeg, June 1980; J.E. Peill, 'Evaluation of a system utilizing straw for crop drying and heating on the farm.' Agriculture Canada Report, March 1980.

Biogas

The economic attractiveness of generating methane (as a fuel for space heating) from animal manure depends on providing sufficient low-cost storage for gas to meet high seasonal demands. For a swine farrow-to-finish operation typical of the farm energy survey farms, the storage of four months' gas production would have to be provided to meet current corn-drying requirements. One-half of the solar collection surface area available on the typical hog farm would provide the maximum digester heat requirement during the grain-drying season.

Existing methane-farm-manure plants have been built not only to provide fuel for powering stationary engines but also to reduce pollution costs. The additional value of increased availability of manure nutrients in the digested sludge can also be credited to the plant. Nitrogen availability may be twice that produced by conventional liquid manure systems. Appendix N shows details of on-farm methane and manure production potential in Ontario.

Direct combustion of biomass

The heat generated by burning various straws, stover, or wood is available for conventional high-temperature grain drying and for space heating. The combustion of 6.5 hectares of corn stover would supply the corn-drying needs for the typical farrow-to-finish farm. One hectare of grain straw could fulfil its heating oil requirements. Appendix O shows straw availability in Ontario.

The question of how much organic material can be safely harvested for burning must also be addressed by farmers now using straw and stover for bedding and feed. If the fuel value of the biomass warrants it, the same amount could be diverted to fuel use and cheaper substitutes found for bedding and feed with no net increase in harvest.

Pyrolysis and gasification

This process uses thermal decomposition of biomass in the absence of oxygen to produce a clean, combustible, low-heat gas and a char product equivalent to coal. Appendix P shows the feedstock needed.

Gasification is an energy conversion process that does not depend on livestock intermediaries anywhere in the system. As such, it could be used on a crop farm. A mobile unit could service several farms as needed. To date the process has not been tried in Ontario, so no reliable estimate can be made of its energy supply potential. The constraints on gasification are that the feedstock must be dry and the need to protect soil fertility limits the amount of biomass that can be removed.

Solar

If low-grade heat from solar collection is to offer the best economic return, it must be usable throughout the year. This principle of maximum utilization of resources applies also to other investments where initial capital costs are high and operating costs are low or negligible.

The majority of solar systems already in use on farms are farm-built or farm-designed. System costs averaging $2 to $6/square foot of collector permit a reasonable return on investments. Commercially available systems costing $25 to $50/square foot are not attractive to farmers.

Conclusions

Non-Farm Energy Supplies

The potential for oil substitution in farm operations exists both in stationary and in mobile applications. The main stationary uses of oil are in crop drying and farm building heating and cooling. The heating, hot water, and cooling in the farm residence are not strictly related to farm production.

About 55 per cent of all direct, on-farm energy use, or about 15TJ, forms the potential for oil substitution in farm operations. In the next five years there are only three possible replacements for this oil: electricity, natural gas, and propane. Natural gas, where available, will be the cheapest replacement. However, the potential to connect a large proportion of oil users to natural gas is considered to be limited. Substitution with electricity in the short term, while attractive for space heating, has significant cost disadvantages in most other uses.

There would also be substantial additional costs of distribution if electricity became a major substitute for oil. Propane therefore is the best immediate possibility for oil replacement in on-farm stationary uses. The actual proportion of on-farm mobile uses to the total has not been estimated, but even if 50 per cent of oil were used for such purposes there would remain the potential to replace up to 227 million litres (250 000 cubic metres) of oil a year in on-farm stationary uses. The farm residence would add further significant potential.

Short-term changes in mobile on-farm oil use are probably difficult to achieve. Existing diesel equipment cannot be easily changed to propane use. Gasoline vehicles can, of course, and gasoline agricultural vehicles should be encouraged to switch to propane. Generally, however, mobile equipment changes to non-oil fuels will only occur gradually as old equipment is replaced. It is not clear at this point whether farm machinery now powered by diesel engines should be encouraged to move to propane, because the overall energy efficiency of diesel engines is superior to that of gasoline or propane engines.

On-farm energy production

There are three possible resources that could be mobilized on individual farms to improve energy self-sufficiency: wastes from existing production, energy crops for on-farm conversion, and renewable sources such as the sun, wind, and wood.

Examination of the overall potential for on-farm energy self-sufficiency leads to two general conclusions. First, the total potential suggests that in terms of programs self-sufficiency through actual on-farm energy production should take a lower priority than conservation programs to improve the efficiency of existing energy uses. Secondly, energy production from specially grown crops to meet on-farm needs will not create problems of displacing foodland for energy production because the self-sufficiency requirement for farms is not large, so that the food/fuel issue does not apply to farm-scale energy self-sufficiency strategies.

Alcohol. There are technologies available for on-farm alcohol production, but they are three or four times more expensive at relatively low prices for corn ($3.00/bu). On-farm small-scale production is approximately twice the cost of commercial-scale production. The best system would combine alcohol production with the use of by-products for animal feed, but even these are relatively expensive compared to conventional feed and fuel. Because of the apparent poor economics of on-farm alcohol production, it is important to await a careful review of the results of the present on-farm demonstration program being implemented by the Ontario Ministry of Agriculture and Food.

Vegetable oils. Oil can be produced from oil seeds on the farm with relatively simple technology. Current tests indicate that sunflower, soybean, and rapeseed oil can be used to replace diesel fuel in tractors and other diesel equipment. The cost of the oil is higher than conventional sources at current on-farm prices but could approach a competitive level more quickly than alcohol. Vegetable oils thus offer a better potential for on-farm energy development than alcohol.

Biomass - direct combustion. This is the most efficient method of converting biomass to energy, but to be economic the waste must be air-dried to about 10 per cent moisture. Handling methods need improvement for more economic applications, and burners must be improved to handle some kinds of biomass such as corn cobs. In calculating potential biomass waste availability a good crop history is necessary, and research should concentrate on how much biomass from crop waste can be removed while still preserving soil fertility.

Producer gas. Producer gas production will have limited applications in very specific circumstances. Development should have a relatively low priority and should emphasize making information available on existing technology.

Animal manure. Of all the farm waste sources for energy production, animal manure has the best potential. It can produce methane and replace energy-based fertilizer. Proper management of manure can achieve both objectives; in fact the integrated system of manure management is most economic. Research and development should concentrate on creating integrated management systems rather than on any one aspect such as anaerobic digestion.

Passive solar systems. There is substantial potential for passive solar systems, both with and without heat storage. Such systems include placement of buildings to take advantage of the directional rays of the sun, specially constructed walls that will catch the sun's heat and circulate it, and heat-catching devices that will store heat in concrete, stone, or water reservoirs. All these systems should cost less than $10 a square foot, and some can now be done for as little as $3 to $5 a square foot, thus making them competitive with other energy sources. A thorough monitoring system is needed to determine the best systems available for on-farm installation.

Active solar systems. The economic applications of active solar systems are very limited at present and are not likely to develop within the next five years. The short-term emphasis in research and development should be on ventilation and air preheating.

Wind. The potential for wind energy in on-farm application will be very limited. It will generally be restricted to remote areas and probably for water pumping at certain sites. Further research and development is needed of the possible applications of wind energy in the agricultural sector.

Wood. A large sustained yield from farm wood lots seems possible, although the actual size of the resource is unclear, and it varies greatly from one region to another through Ontario. For example, outside southeastern Ontario, wood will be available in limited quantities. The major advantage of wood, where available, is that at present prices in efficient applications it is competitive with oil, particularly in farm residences.

FOODLAND DEVELOPMENT

Land management

Land productivity

The research reports and briefs indicated that while there is sufficient improved land in Ontario to satisfy the present demand for food production, a growing domestic population and an expanding export market will make it essential that a further 1.1 million hectares of land be improved and brought into production by the year 2000.

Rising energy prices will make it more profitable to use climatically superior or warmer lands in southern Ontario more intensively. Lands that are farther north, cooler, or poorly drained will require a higher input of energy to bring them to maximum production.

If all of the foodland in southern Ontario is retained in use and farmed with maximum efficiency, there appears to be more than enough to provide food for the population of Ontario to the year 2000 and to supply an expanding export market. If significant areas are lost to other uses (urban development, forestry, recreation) it will be necessary to bring more northerly foodland into production. But it is not advisable to reduce the best agricultural land in the hope of making it up from land in cooler regions when energy is scarce or expensive.

It is important to know more about the nature of microclimates such as those in the Niagara Peninsula, the Blenheim area, the Simcoe area, and the Alliston-Collingwood area. It will also be necessary to know what impact rising energy costs will have on the extent of urban use of farmland, what additional rural lands would be required to increase Ontario's self-sufficiency in food, what additional lands may be needed for fuel production in the form of either hybrid poplar or agricultural crops, and what the land requirements may be for park and recreation space.

Land preservation

Land use monitoring should be stepped up to provide the data base required for effective land-use management. The food industry will be expected to produce substanially higher output per hectare of land and per unit of energy consumed. Significant changes may be required in the ways in which crops and livestock are combined to reduce dependence on energy while increasing total output of food. Land requirements may be affected.

The new Draft Planning Act will rely on a partnership between the Province and the County or Region to develop and preserve foodland in the most suitable way. To work effectively in this partnership, both sides need better information on land and on local rural input.

Production management

Field crops

The research reports commissioned by the Committee differ to some extent on the precise numbers involved, but it appears that about 4.4 million hectares of foodland were devoted to field crops in Ontario in 1980 and that even with productivity gains about 5.5 million hectares will be needed in the year 2000 to maintain Ontario's current level of food self-sufficiency. Since there are about 3.7 million hectares of Class 1-4 foodland in southern Ontario and 650 000 hectares of Class 3-4 foodland in northern Ontario, it will be necessary to increase the productivity of Ontario's foodland and preserve it from other uses. If Ontario's exports of food are to be expanded, still more climatically flexible land will be needed.

The future planning for agricultural production under conditions of constrained and expensive energy and land in Ontario must be undertaken on a systems basis. For example, drainage activity should be increased to at least double present levels. At least 1.6 million hectares could be drained in Ontario, and some existing drains must be replaced. Present drainage activity will not come close to meeting such a goal.

Animal products

It is difficult to forecast the future of Ontario's livestock industry since it is so open to competition from other parts of Canada, the United States, Australia, and the EEC. The scale of livestock operations in Ontario depends directly on many factors, including the decisions of Prairie farmers to produce livestock instead of grain, the development of new technology (grain storage, high-moisture corn systems, the use of brewer's stillage, etc.), taste changes (such as a preference for butter or margarine), and changes in exports of meats or breeding stock.

If forecasts of doubled grain exports in the next decade are realized, western grain farmers will probably concentrate still more on grain production, reducing livestock herds even further. This provides Ontario with an opportunity to grow more livestock, but it may reduce the supply of calves available for finishing in Ontario. In turn, such a development would open up an opportunity for cow-calf operations in areas of Ontario where land is less expensive but where forage can be grown.

The complexity of the livestock situation shows the need for a systematic approach to be taken in future planning, especially under conditions of scarce resources and energy.

All types of farm operations, including cash crop, livestock, and combined crop-livestock systems should be examined on an energy input/output basis. Extension programs can then be focused on assisting farmers to improve energy input/output ratios.

ENERGY PRODUCTION FROM AGRICULTURE

The production of energy from agricultural resources raises the economic and moral issue of whether foodland should be devoted to energy production. The Committee's examination of large-scale energy production from agricultural resources therefore made two fundamental assumptions.

First, the quantity and cost of conventional crops that will be supplied as feedstock to a plant for conversion to fuel is going to be determined by world prices for those crops. Other crops grown in a particular locality specifically for energy production have to be able to compete for resources against other uses whose return on resources is ultimately determined by world markets. Only in these circumstances can the real cost of the fuel produced be properly determined.

Secondly, it was assumed that present agricultural output would at least be maintained and expanded to meet a growing population, so that energy production would have to be undertaken on land surplus to these requirements. Consequently the land requirements of energy crops were an important element. The large-scale energy potential of agricultural crops was analysed in light of tentative targets for production, together amounting to a target of 570 000 cubic metres (3.6 million barrels) of oil equivalent by 1985.

Energy potential of crops

Crop yields in tonnes per hectare and the associated fuel yield per tonne are summarized for each crop in Table 3.12. To compare crops directly in terms of actual energy output, these yield values are converted to barrels of oil (crude) equivalent (BOE) but do not reflect any increased efficiency that may result from the burning of ethanol, for example, in comparison to gasoline refined from crude oil. The crops are compared by energy content only.

TABLE 3.12

Physical characteristics and potential yields of energy crops

	Crop yield (tonnes/ha)	Fuel yield (litres) /tonne of crop	Bbls oil equiv. (BOE)	
			/tonne of crop	/ha
Ethanol from:				
Winter Wheat	3.46	410	1.58	5.53
Oates	2.22	270	1.03	2.22
Barley	2.96	390	1.50	4.59
Grain corn	5.69	430	1.65	9.34
Potatoes	23.47	111	0.42	9.86
Sugar beets	44.46	70	0.27	12.01
Jerusalem artichokes (tubers)	44.46	113	0.43	19.12
Jerusalem artichokes (tops)	88.92	91	0.34	30.23
Oil from:				
Soybeans	2.22	198	1.17	2.74
Sunflowers	1.73	431	2.57	4.62
Rapeseed	1.73	442	2.61	4.82
Crude from milkweed	7250L to 14500L			28.23 56.46
Hybrid poplar: Methanol	7.5 o.d.t./ha	550 (methanol)	1.63	11.12
: Ethanol & Methanol	7.5 o.d.t./ha	300 (ethanol +100 (methanol)	1.44	9.83

High-potential crops

No firm data are available concerning the yield responses of Jerusalem artichokes and milkweed. We have only rough estimates received from individuals working with those crops in the United States, and these estimates have yet to be duplicated in Ontario. Greater detail on each potential crop is given in Research Report 8.

Oil from milkweed could have the highest potential of all crops considered. Jerusalem artichokes, sugar beets, and hybrid poplar plantations also rank high, although poplar production may be better devoted to direct combustion for generation of electricity and possibly steam.

Other potential crops

Some other crops also show promise as possible energy producers, though to a lesser extent than those discussed above. Jerusalem artichoke tubers harvested for ethanol production seem to indicate high yields but at relatively high costs and considerable risk. Hybrid poplar production for conversion to ethanol also appears to make good use of land. Grain corn used for ethanol is in the mid-range in cost, but the grain corn area would have to double in order to reach the oil-equivalent output target.

Oil from rapeseed would appear to be cheaper fuel than ethanol from corn. It would require larger areas than corn but can be grown in cooler climates and thus has potential for development of northern Ontario farm production.

Oil from sunflowers appears to have potential on a cost basis, but it would require large areas of land in good farming areas.

Crops with little potential

Barley is cost-competitive with corn for ethanol production, but it requires much more land. However, it would be a suitable rotation crop with rapeseed in northern Ontario.

Soybeans, winter wheat, oats, sugar beets, and potatoes appear to have cost and land use disadvantages significant enough to eliminate them from the list of potential crops for fuel production.

Net energy considerations

There are several ways of estimating the net energy balance for conversion of feedstock to ethanol or methanol, and there is some debate about whether to measure just fossil fuel consumption in the conversion process or total energy.

It appears that with many technologies the total energy requirement for the conversion process is close to the total energy produced in the process.

Since milkweed crude would be subject to approximately the same energy balance as fossil fuel crude refining, the total cost of conversion to usable fuel would be only some 10-12 per cent - another big advantage of milkweed.

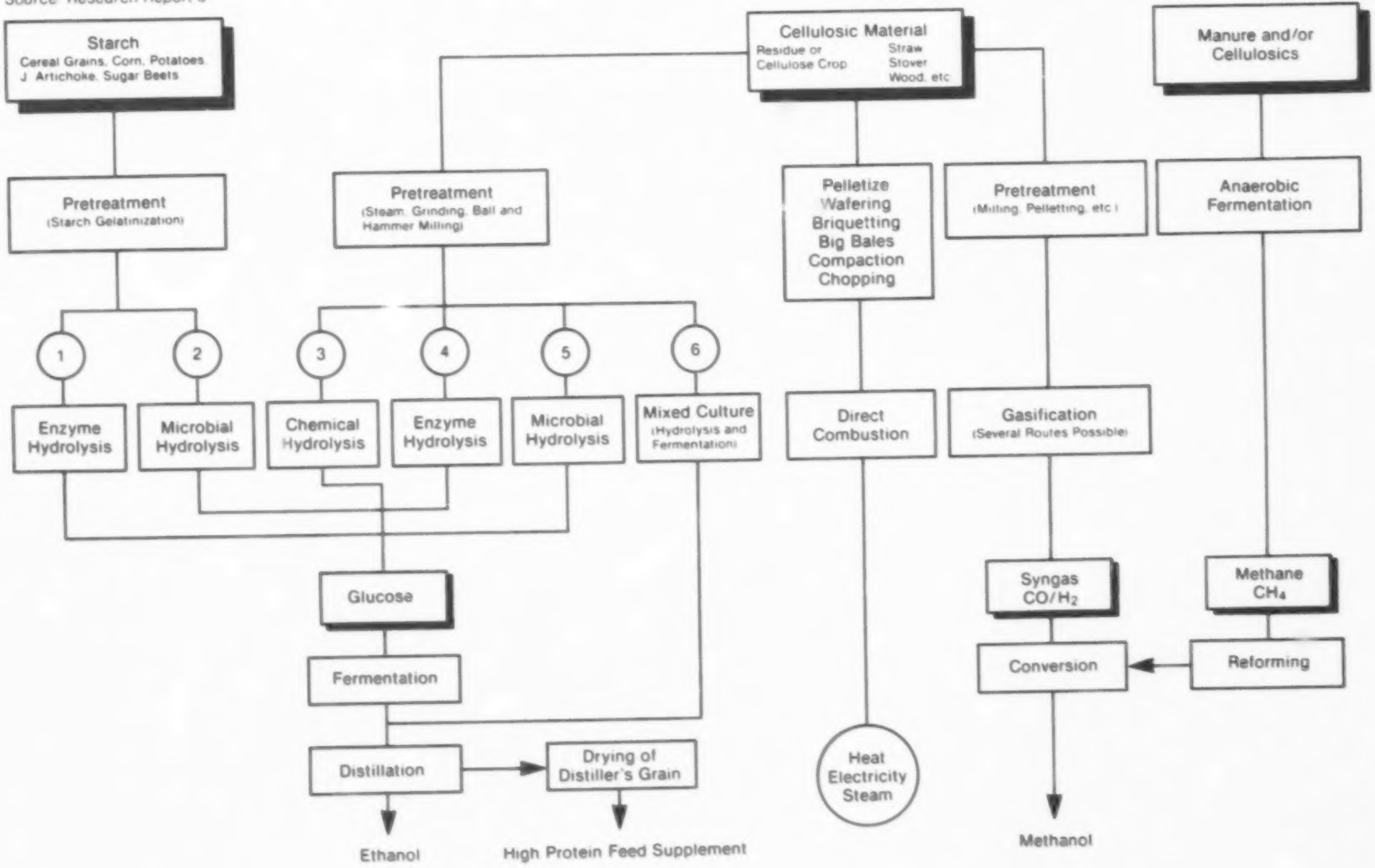
Similarly, the energy efficiency of converting rapeseed oil to usable fuel is expected to be very high in that it involves only filtering and the addition of a solvent to prevent gumming up of diesel engines. The technologies available for large-scale energy production from agricultural crops are discussed in Appendix Q and shown in Figure 3.4.

Cost of production

The major premise of the analysis is that market forces of supply and demand have been working quite efficiently to allocate Ontario's agricultural resources to their best use (in terms of efficient resource utilization). The cost of conventional crops supplied as feedstock to a plant for conversion to fuel is going to be determined by worked prices for those crops. Research Report 8 uses grain corn as an example to show how market forces tend to make the cost of production similar in different regions and soil types and approximately equal to expected market value.

Figure 3.4 Conversion technologies for energy from biomass

Source Research Report 8


Starch
Cereal Grains, Corn, Potatoes, J. Artichoke, Sugar Beets
Cellulosic Material
Residue or Cellulose Crop
Straw
Stover
Wood, etc
Manure and/or Cellulosics
Pretreatment
(Starch Gelatinization)
Pretreatment
(Steam, Grinding, Ball and Hammer Milling)
Pelletize
Wafering
Briquetting
Big Bales
Compaction
Chopping
Pretreatment
(Milling, Pelletting, etc.)
Anaerobic Fermentation
1
2
3
4
5
6
Enzyme Hydrolysis
Microbial Hydrolysis
Chemical Hydrolysis
Enzyme Hydrolysis
Microbial Hydrolysis
Mixed Culture
(Hydrolysis and Fermentation)
Direct Combustion
Gasification
(Several Routes Possible)
Glucose
Syngas
CO/H₂
Methane
CH₄
Fermentation
Conversion
Reforming
Distillation
Drying of Distiller's Grain
Heat
Electricity
Steam
Ethanol
High Protein Feed Supplement
Methanol

The effective cost of agriculturally produced feedstock for fuel production is thus the Ontario market value of the crop, which is equivalent to the world price adjusted for exchange rates, cost of transportation, and so on. This market price has been used as the cost of feedstock when considering world-traded commodities. For comparative purposes, the 1980 cost of production budgets has been included in Research Report 8 for major conventional crops, though market values were used to determine feedstock costs.

For possible energy crops with no established market price, budgeted costs of production have been used. These estimates should approximate the break-even price necessary for a producer to consider diverting his productive resources from production of conventional commodities to production of new crops for energy production. In practice, because of uncertainties surrounding production and cost coefficients and the potential marketing problems of a totally new and unfamiliar crop, a price much higher than the budgeted break-even price would probably be necessary before any significant quantities would be forthcoming from potential producers. Production of new energy crops would also entail additional costs to establish appropriate infrastructure (specialized services and supplies, transportation and processing facilities, markets for by-products, dissemination of management experience and expertise, and so forth).

The costs of converting crops to fuels are mostly unknown at this point. Estimates vary widely depending on the type of technology, expected advances in technology, the extent of experience with the process, and other conditions. The relevant literature abounds with serious reservations about the validity of conversion cost estimates. It seems that risking capital on demonstration plants is the only way to get a reliable estimate of costs of conversion. Nevertheless, in order to assess the economic potential of an agriculturally based fuel supply, some very rough cost estimates had to be used to make possible comparisons with conventional fossil fuels.

Tables 3.13 and 3.14 show estimates of the feedstock and conversion costs for various fuel crops to get an approximation of the 1980 cost of fuels at the plant gate ready for distribution. On a cost basis, milkweed seems to offer the most attractive alternative to conventional fossil fuels ($30-51/BOE), followed by methanol from hybrid poplar ($77/BOE), oil from oilseeds ($61-97/BOE), and ethanol from barley, grain corn, and Jerusalem artichoke tops ($98-100/BOE). Once again, these estimates are very tentative.

The opportunities identified above fall into two basic categories: those that compete directly with food for land and those that use land not currently devoted to agriculture or land marginal for food production. The crops that compete for foodland all require integrated systems of energy production and by-product use in animal production. (As Table 3.13 shows, all foodcrops have substantial by-product credits which would be essential to make such crops viable for energy production.)

The by-product question has two important implications. First, energy production from agricultural resources is not strictly a question of food vs fuel. The production of fuel may simply mean a reordering of how the agricultural output is used, i.e. first for fuel and secondly for food production. Furthermore, large-scale energy production with proper by-product use would have serious effects on the livestock industry that would have to be carefully considered before energy production from an agricultural crop was undertaken.

Land resources

In the southern regions of Ontario, there appears to be no significant reserve of arable land that can be brought into production of conventional crops at present cost/price relationships. There is perhaps potential for some 610 000 hectares of mostly Class 4 land if suitable and profitable crops are found - perennials such as hybrid poplar, milkweed, and Jerusalem artichokes (for tops) are possibilities. (A more thorough discussion of land use and availability is presented in Research Report 7.)

TABLE 3.13

Feedstock costs for fuels

	Gross feedstock cost			By-product credit		Net feedstock cost	
	$/tonne	¢/litre	$/BOE	¢/litre	$/BOE	¢/litre of fuel	$/BOE
For ethanol							
Winter wheat	216	53	140	16	42	37	98
Oats	132	49	129	25	66	24	63
Barley	144	37	98	17	45	20	53
Grain corn	153	36	95	16	42	20	53
Potatoes	132	119	314	17	45	112	295
Sugar beets	38	54	143	11	29	43	114
J. artichokes (tubers)a	42	37	98	11	29	26	69
J. artichokes (tops)b	12	14	37	?	?	14	37
Oilseed oil							
Soybeans	328	165	279	118	199	47	80
Sunflowers	253	69	100	28	47	31	53
Rapeseed	310	70	118	25	42	45	76
Milkweed crude							
Lower yield	--	25	39	--	--	25	39
Potential yield	--	12	20	--	--	12	20
Hybrid poplar							
Methanol process	42	8	26	--	--	8	26
Ethanol process	42	11	30	--	--	11	30

SOURCE: Research Report 8

a) By-product credit includes distillers residue only, nothing for tops.
b) No credit given for by-products since not known, although apparently good potential.

TABLE 3.14

Approximate total costs of fuels

	Net feedstock cost		Conversion cost		Total cost (excl. taxes & distribution	
	¢/litre	$/BOE	¢/litre	$/BOE	¢/litre of fuel	$/BOE
Gasoline from						
Cdn crude oil at $17.50 bbl.:	11.0	19.36	4.3	7.57	15.3	26.93
W.O.P. $35/bbl:1/	22.0	38.72	4.3	7.57	26.3	46.29
Milkweed crude:						
at $20/bbl	13	22	4.2	7.57	17	30
at $39/bbl	25	43	4.3	7.57	29	51
Ethanol from						
Winter wheat	37	98	17	45	54	143
Oats	24	63	17	45	41	108
Barley	20	53	17	45	37	98
Grain corn	20	53	17	45	37	98
Potatoes	112	295	24	63	136	328
Sugar beets	43	114	24	63	67	187
J. artichokes (tubers)a	26	69	24	63	50	132
J. artichokes (tops)b	14	37	24	63	38	100
Oil from						
Soybeans	47	80	10	17	57	97
Sunflowers	31	53	5	8	36	61
Rapeseed	45	76	5	8	50	84
Hybrid poplar						
(a) Methanol process	8	26	15	51	23	77
(b) Ethanol process	(2 fuels)	30	(2 fuels)	?	?	?

a) By-product credit includes distiller's residue only, nothing for tops.

b) No credit given for by-products since not known, although apparently good potential.

NOTE: Feedstock cost from Canadian Resourcecon Ltd, Chap. 40. Oilseed conversion cost $20/tonne for crushing only. No estimates are available for ethanol from hybrid poplar.

Northern Ontario appears to have a reserve of up to 1.25 million hectares of Class 3 land that may be suitable for short-season crop production such as rapeseed, oats, and barley. Hybrid poplar of course may also produce well there, and perennial milkweed and Jersualem artichokes (for tops) are also possibilities.

In terms of land-use implications, milkweed seems the best alternative if the estimates are at all close. Jerusalem artichokes and hybrid poplar are also possibilities. Of the oilseed crops, rapeseed has some potential to contribute to the fuel target if feasible in northern Ontario. The other crops appear to have prohibitive land requirements in light of the target of 3.6 million BOE annually.

Conclusion

Ontario has two targets for annual energy production from agricultural and related biomass: 3.6 million BOE from agricultural biomass such as corn, soybeans, or other crops and 5.9 million BOE from hybrid poplar production. The Committee believes that these targets are ambitious and raise the fundamental issues of whether foodland should be used for energy production and whether the importance of food production should overshadow market forces which might push land that is used for food into energy production. It was concluded that while market forces would generally prevail, policy instruments over which the government has control should be used to minimize the conflict between energy and food production. For example, it was concluded that hybrid poplar could be encouraged for wet and stony lands that are not suitable for agricultural crops. The possible future development of cellulosic fermentation might of course avoid the food/fuel conflict. But the Committee believed that demonstration and development of hybrid poplar for energy production should be concentrated only on adaptable land types such as Classes 4 to 6. The only exceptions to this general guideline would be where there are regional economic development objectives that make the use of agricultural land for energy production a reasonable decision and where agricultural land is now economically underutilized, as in northern or eastern Ontario.

Ethanol production

The production of ethanol on a commercial scale is possible with existing technology, but it would only be competitive at a price of \$75-100 per barrel of oil (\$472-629/m^3). This competitive level will rise as the cost of energy rises in general, so that the break-even point between ethanol and conventional fuel will not narrow as quickly as it would if only conventional energy prices where rising. Because of this wide differential between the cost of ethanol and conventional oil, it was concluded that with ethanol priced at the synthetic fuel level (such as for tar sands) it would not be competitive within the foreseeable future. The only justification for production would appear to be security of supply, and ethanol fuels would then require subsidized prices.

A number of major problems with ethanol production must be carefully appraised before any decision is taken to proceed with commercial production. First, a plant with an annual output of 20 million gallons would be sufficient to support one-third of the existing feeder cattle population of Ontario if the by-products were used for feed, and this must be done in order to justify or improve the economics of such a plant. Therefore the integration of the plant into the existing livestock industry must be studied very carefully. This means either choosing a location where there are sufficient feeder cattle within 25 to 50 miles of the plant or reorganizing the industry over a longer term to localize beef production near the plant. Another problem in need of careful study and on which information is sketchy is the treatment of effluent from both the ethanol plant and the highly concentrated animal production. Probably no more than one commercial-scale plant could be justified under any circumstances, but more research on this point is necessary. The Committee supports the undertaking of a full technical and economic feasibility study of ethanol based on grain corn as has been proposed by the Ontario Energy Corporation. Small grains should not be considered for energy production.

Oil production

Oil seeds and milkweed both appear to have potential for the production of oil on non-competitive land types particularly in the north. The production of rapeseed on poorer quality lands in the north requires further research and demonstration. Milkweed on the other hand may have a large potential output, but data are lacking on the economics and technical feasibility of using milkweed as an energy crop. One significant danger in developing milkweed is that it is a considerable nuisance to farmers throughout Ontario, and indiscriminate cultivation could increase this problem and have potential harmful effects on food output, even if it were produced on non-conflicting land. But there is a need for research into the whole system of growing, control, and conversion of milkweed to energy.

Hybrid poplar

The growth of hybrid poplar for energy production to meet the Ontario target of 5.9 million BOE is not, strictly speaking, an agricultural problem, although it could overlap onto agricultural land. If the program should go ahead, 400 000 hectares of land would be needed to meet the target. It should be possible to find non-competing land sources of this magnitude in Ontario.

USE OF INDUSTRIAL WASTE HEAT

Expansion of greenhouse vegetable production to replace vegetable imports could be based on the use of waste heat that is available as a by-product of industrial production. The Committee's findings, based on Research Report 6, are summarized in this section.

Potential amount of waste heat available

Appreciable quantities of energy are available as discharged, but recoverable, waste heat from Ontario industries. The total rejected energy has been calculated to be 905.6PJ annually, of which an estimated 235.7PJ, or more than one-quarter, could be recovered for use. Half of the total rejected energy is low-grade heat at less than 120°F, whereas the 120-212°F reject heat stream constitutes 9 per cent. Since energy conservation practices within industry are likely to lead in future to greater internal cascading of high-temperature waste heat, it is possible that mainly low-grade heat will be available for food production.

Three major industries produce 78 per cent of the total waste heat: electricity generation, primary metals, and pulp and paper. Eleven industry divisions produce an average recoverable energy of more than 1.1 GJ per hour per site. The total recoverable energy from these industries is 29.0TJ an hour, which would supply the winter heat load of 5500 hectares of conventional greenhouses.

The natural gas pipeline compressor stations in Ontario that are in operation for more than 50 per cent of the time produce high-temperature waste heat, of which an estimated 2.4 PJ a year is recoverable. This would provide the winter heat load for 55 hectares of conventional greenhouses.

A key issue in the utilization of reject heat for food production is to match the demand with the supply. Since the demand is seasonal, priority might well be given to the utilization of waste heat at those industrial plants (and pipeline compressor stations) that produce a maximum in winter and a minimum in summer.

When the supply of waste heat is virtually a constant over the year, the preferred method of utilization is to build flexible systems through which the energy is cascaded (used at successively lower temperatures) as appropriate. Such systems can also produce both greenhouse crops and field crops to replace imports.

The three-month winter heat load of a conventional greenhouse constitutes half of its total annual energy demand. Thus a flexible system could incorporate the cascading of heat through greenhouses to aquaculture in winter and the diversion of heat to soil-warming and field crop irrigation in summer. A further alternative is to expand and contract the capacity of the food production facility in accordance with seasonal changes in energy demand to match a constant energy supply. Priority may well be given to establishing greenhouses at industrial heat sources which can ensure an uninterrupted supply, thereby eliminating the cost of providing a second backup heating system.

The current (1979) cost of heating conventional greenhouses in year-round operation in Ontario is approximately $158 000 a hectare. The capital cost of greenhouse construction is currently between $500 000 and $1 000 000 a hectare, depending upon the design and the type of covering. Accelerated research is needed to develop innovative and less expensive greenhouse structures particularly suited to industrial locations. The potential use of closed and non-insulated growth chambers with high-efficiency lighting merits serious attention, particularly for installation at industries which operate on a single eight-hour shift.

Potential food production from waste heat

The use of low-grade heat for soil warming in field crop production can advance the growing season and increase yields by 30 per cent. The profit per hectare could be doubled.

Aquaculture is a viable method of utilizing low-grade heat, particularly if the polyculture of warm-water species is developed. Research is needed in this connection. The major product of aquacultural systems utilizing industrial waste heat could be protein for animal feed. Thus many fish species other than those acceptable for human consumption become candidates for culture. Since aquatic life is highly susceptible to damage from pollutants, a greater risk is involved in aquaculture than in soil heating for plant propagation.

The food imports most suitable for replacement by production in Ontario using industrial waste heat sources are fresh vegetables. These have an import value of $130 million annually, and at least 27 million litres of diesel fuel are consumed in their transportation from all over North America. In terms of import replacement, priority for greenhouse production using waste heat should be allocated to tomatoes and lettuce, then to celery, peppers, and cucumbers. The priority crops for soil heating and/or warm water irrigation are potatoes, then onions and carrots.

About one thousand hectares of greenhouse would be needed to replace the imports of the top five vegetable crops. This would use only 17 per cent of the recoverable waste heat available and would save at least 17 million litres of transport fuel a year. Replacement of the annual imports of 19 000 tonnes of tomato paste might best be achieved by an increased and irrigated area of field production. About 15 000 hectares of soil warming systems could produce the crops to replace all fresh vegetable imports, including potatoes (excluding potatoes about 10 000 hectares would be needed), and the estimated installation cost would be $4.3 billion (implying a payback period of about six years). However, the total (capital and operating) cost per unit of production is much less for greenhouse cultivation than for field propagation by soil warming, so the latter is difficult to justify except for crops not suitable to greenhouses.

The 1000-hectare greenhouse area mentioned above to replace imports of the top five fresh vegetables would require a capital investment of between $500 million (new design) and $1000 million (conventional designs). But the annual saving on imports to Ontario would be $110 million, and apart from construction about 11 500 new jobs would be created.

APPENDICES

APPENDIX A

Research Reports Received by the Committee

Background Material (Consultant's reports):

Report #

1. The Role of Energy in Ontario Agriculture: Consumption, Costs, Relative Importance and Effects on Imports for 1978, 1985 and 2000; T.M. Rothwell; 2 Jan. 1981.

   plus companion documents:

   a) Energy Consumption and Costs in the Ontario Mushroom Industry 1978, 1985 and 2000; T.M. Rothwell; 15 Dec. 1980.

   b) Imports and Interprovincial Movements of Food Supplied into Ontario 1978 and 1979; P.H. Southwell; 1980.

2. Report on Energy Conservation on Ontario Farms; R. Lay; 15 Dec. 1980.

   Report on Energy Production on Ontario Farms; R. Lay; 15 Dec. 1980.

   plus appendices:

   I - Agriculture Production per Farm, by Farm Type

   - Specific Energy Requirement per unit of Agricultural Production per Farm, by Farm Type

   II - Propane Substitution Potential

   - Consumption of Propane; Heating Oil, Gasoline; per Farm, by Farm Type

   III - Farm Resources, by Farm Type

     - Production
     - Energy Requirements
     - Potential for Solar, Methane and Manure Nitrogen Production

   IV - Data: Potential for Solar Collection by Farmstead Buildings

   plus companion document:

   Report on the Farm Energy Survey for the Agricultural Energy Policy Committee; R. Lay; 15 Dec. 1980.

3. Ontario Greenhouse Industry: An Energy Perspective: H. Tiessen; J. Tsujita; R. Evans; Nov. 1980.

4. Final Report: Transportation of Farm Products; Boston Gilbert Henry Associates Ltd., 14 Jan. 1981.

5. Propane as a Substitute Fuel in the Ontario Agriculture Sector; Crandall Energy Consultants Ltd., Nov. 1980.

6. Potential for the Utilization of Industrial Waste Heat for Food Production.

7. Impacts of Energy Supplies Upon Land Needs for Agriculture in Ontario; Centre for Resources Development, University of Guelph; Nov. 1980.

8. Potential for an Agriculturally-Based Fuel Supply in Ontario; Broadwith, Hughes and Associates Ltd., 15 Dec. 1980.

APPENDIX B

Assumptions in the CLI soil capability for agriculture system

1 The system applies only to common field crops such as corn, oats, wheat, and barley.

2 The classification covers mineral soils only.

3 The system takes into account the combination of climate and soil characteristics on the productivity of common field crops, limitations to use for agriculture, and risks of soil damage.

4 The classification system is based upon the data published in the soil survey maps and reports.

5 A soil can only be placed in Class 1 if there are no significant limitations.

6 Where climate is the only limiting factor, a Class 1 soil must be in an area that receives 2300 Corn Heat Units or more.

7 Good soil management practices that are feasible and practical under a largely mechanized system of agriculture are assumed.

8 Soils considered feasible for improvement by draining, irrigation, removing stones, altering soil structure, or protecting from overflow of water are classified according to their continuing limitation or hazards to use *after* the improvements are made.

9 If the same level of management is applied to two soils that are classified differently, the soil with the higher classification will be greater in productivity.

APPENDIX C

Total energy consumption for crop production, 1978 (energy in TJ, cost in $000)

Crop (Hectares)		Natural Gas	Fuel Oil	Diesel Fuel	Gasoline	Propane	Electricity	Pesticide Formulation	Total
Barley and mixed grains (469 830)	Energy	1485	238	973	105	0	72	0	2 873
	Cost	3450	753	3868		0	336	0	8 407
Oats (193 440)	Energy	355	80	390	40	0	21	0	887
	Cost	825	216	1540	192	0	95	-	2 868
Winter wheat and rye (157 440)	Energy	762	116	341	35	0	39	0	1 293
	Cost	1772	313	1378	171	0	177	-	3 811
Grain corn (660 440)	Energy	7717	1102	1622	159	815	222	92	11 729
	Cost	17396	2961	6651	961	3101	1044	-	32 114
Silage corn (343 980)	Energy	3189	574	1098	82	0	100	48	509
	Cost	7407	1542	4432	501	0	465	-	14 347
Soybeans (220 550)	Energy	373	108	108	75	0	38	145	847
	Cost	868	292	1630	456	0	165	-	3 411
White beans (55 440)	Energy	84	33	97	37	0	15	37	303
	Cost	195	86	395	187	0	-	-	863
Haylage hay (1 139 980)	Energy	829	1065	3399	93	0	227	62	5 675
	Cost	1926	2860	13790	562	-	1038	-	20 176

APPENDIX C cont'd

Total energy consumption for crop production, 1978 (energy in TJ, cost in $000)

Crop (Hectares)		Natural Gas	Fuel Oil	Diesel Fuel	Gasoline	Propane	Electricity	Pesticide Formulation	Total
Pasture	Energy	442	724	643	53	0	7	0	1 869
(712 240)	Cost	1026	1944	2984	318	0	661	-	6 933
Apples	Energy	105	7	5	61	0	143	10	331
(10 301)	Cost	244	43	26	286	0	140	-	739
Grapes	Energy	82	17	6	54	0	10	4	173
(10035)	Cost	192	45	32	248	0	45	-	562
Peaches	Energy	22	4	2	20	0	3	4	55
(3713)	Cost	51	-	9	118	-	10	-	188
Cabbage and	Energy	13	3	2	24	0	1	6	49
cauliflower	Cost	30	10	9	104	0	5	-	158
(2083)									
Carrots	Energy	7	29	6	15	0	1	1	58
(1571)	Cost	17	6	24	67	0	3	-	117
Celery	Energy	3	1	1	2	0	1	1	6
(208)	Cost	7	2	2	9	0	1	-	21
Cucumbers	Energy	13	2	1	17	0	1	1	35
(2426)	Cost	29	7	6	78	0	4	-	124

APPENDIX C cont'd

Total energy consumption for crop production, 1978 (energy in TJ, cost in $000)

Crop (Hectares)		Natural Gas	Fuel Oil	Diesel Fuel	Gasoline	Propane	Electricity	Pesticide Formulation	Total
Sweet corn, fresh (2375)	**Energy**	16	3	1	6	0	1	2	29
	Cost	37	8	7	27	0	5	-	84
Sweet corn, processing (15 208)	Energy	102	19	7	39	0	3	12	182
	Cost	238	51	42	174	0	3	-	508
Lettuce (5211)	Energy	4	1	1	3	0	1	1	8
	Cost	9	2	2	15	0	1	-	29
Onions (2103)	Energy	23	5	1	16	0	2	5	52
	Cost	54	14	9	76	0	8	-	161
Peas (9397)	Energy	14	4	19	13	0	1	2	53
	Cost	31	11	75	58	0	8	-	183
Potatoes (18 199)	Energy	198	39	195	12	0	10	7	461
	Cost	460	104	773	70	0	59	-	1 466
Rutabagas (1513)	Energy	6	2	6	3	0	1	1	19
	Cost	15	6	26	16	0	5	-	68
Tomatoes, fresh (1045)	Energy	13	3	1	5	0	1	3	26
	Cost	30	8	7	27	0	5	-	77

APPENDIX C cont'd

Total energy consumption for crop production, 1978 (energy in TJ, cost in $000)

Crop (Hectares)		Natural Gas	Fuel Oil	Diesel Fuel	Gasoline	Propane	Electricity	Pesticide Formulation	Total
Tomatoes,	Energy	59	26	15	56	0	10	27	193
processing	Cost	136	71	77	251	0	41	-	576
Mushrooms	Energy	465	62	67	34	-	126	-	754
	Cost	1080	173	310	193	-		573	2 329
Greenhouses	Energy	2586	3302	-	-	627	-	-	6 515
	Cost	7658	13346		-	420	-	-	21 424
Total	Energy	18967	7568	9 006	1 080	1 442	919	469	39 451
	Cost	45724	24885	38 104	5 645	3 521	4 842		121 744

NOTE: A line under a number means 'less than'.

APPENDIX D

Energy costs for crop production, 1978 ($ per acre)

CROP	Nat. Gas	Fuel Oil	Diesel Fuel	Gasoline	Propane	Electricity	Total
Barley, Mixed Grains							
- field operations			2.88	0.27			3.15
- fertilizer	2.96	0.60	0.45	0.11		0.28	4.40
- pesticides	0.01	0.05		0.06		0.01	0.13
	2.97	0.65	3.33	0.44		0.29	7.68
Oats							
- field operations			2.88	0.27			3.15
- fertilizer	1.72	0.40	0.34	0.08		0.19	2.73
- pesticides	0.01	0.05		0.06		0.01	0.13
	1.73	0.45	3.32	0.41		0.20	6.01
Winter wheat, Rye							
- field operations			2.88	0.27			3.15
- fertilizer	4.55	0.80	0.66	0.17		0.46	6.64
- pesticides							
	4.55	0.80	3.54	0.44		0.46	9.79
Grain corn							
- field operations			3.08				3.08
- fertilizer	8.36	1.03	0.99	0.13		0.46	10.97
- pesticides	0.36	0.78		0.46		0.09	1.69
- drying	2.27				1.90	0.09	4.26
	10.99	1.81	4.07	0.59	1.90	0.64	20.00
Silage corn							
- field operations			4.22				4.22
- fertilizer	8.36	1.03	0.99	0.13		0.46	10.97
- pesticides	0.36	0.78		0.46		0.09	1.69
	8.72	1.81	5.21	0.59		0.55	16.88
Soybeans							
- field operations			2.41				2.41
- fertilizer	1.51	0.52	0.58	0.09		0.27	2.97
- pesticides	0.09	0.01		0.74		0.07	0.91
	1.60	0.53	2.99	0.83		0.34	6.29
White beans							
- field operations			2.28	0.67			2.95
- fertilizer	1.04	0.55	0.61	0.09		0.28	2.57
- pesticides	0.38	0.08		0.60		0.16	1.22
	1.42	0.63	2.89	1.36		0.44	6.74

APPENDIX D (cont.)

Energy costs for crop production, 1978 ($ per acre)

CROP	Nat. Gas	Fuel Oil	Diesel Fuel	Gasoline	Propane	Electricity	Total
Haylage, hay							
- field operations			3.82				3.82
- fertilizer	0.68	1.01	1.08	0.17		0.37	3.31
- pesticides				0.03			0.03
	0.68	1.01	4.90	0.20		0.37	7.16
Pasture							
- field operations			0.54				0.54
- fertilizer	0.58	1.10	1.16	0.18		0.38	3.40
- pesticides							
	0.58	1.10	1.70	0.18		0.38	3.94
Apples							
- field operations				7.89			7.89
- fertilizer	8.70	1.69	1.02	0.32		0.63	12.36
- pesticides	0.88	0.01		3.02		0.92	4.83
	9.58	1.70	1.02	11.23		1.55	25.08
Grapes							
- field operations				7.71			7.71
- fertilizer	5.88	1.79	1.29	0.27		0.59	9.82
- pesticides	1.86	0.04		2.02		1.23	5.15
	7.74	1.83	1.29	10.00		1.82	22.68
Peaches							
- field operations				8.62			8.62
- fertilizer	3.34	1.18	0.97	0.21		0.42	6.12
- pesticides	2.26	0.03		0.76		0.63	3.68
	5.60	1.21	0.97	9.59		1.05	18.42
Cabbage & cauliflower							
- field operations				19.70			19.70
- fertilizer	5.72	1.85	1.81	0.33		0.90	10.61
- pesticides	0.06	0.01		0.22		0.05	0.34
	5.78	1.86	1.81	20.25		0.95	30.65
Carrots							
- field operations			5.03	15.34			20.37
- fertilizer	3.19	1.46	1.27	0.25		0.49	6.66
- pesticides	1.24	0.13		1.54		0.42	3.33
	4.43	1.59	6.30	17.13		0.91	30.36

APPENDIX D (cont.)

Energy costs for crop production, 1978 ($ per acre)

CROP	Nat. Gas	Fuel Oil	Diesel Fuel	Gasoline	Propane	Electricity	Total
Celery							
- field operations				15.95			15.95
- fertilizer	12.59	4.07	3.22	0.72		1.24	21.84
- pesticides	1.86	0.16		1.71		0.57	4.30
	14.45	4.23	3.22	18.38		1.81	42.09
Cucumbers							
- field operations				12.73			12.73
- fertilizer	4.69	1.07	1.03	0.16		0.58	7.53
- pesticides	0.14	0.01		0.05		0.12	0.32
	4.83	1.08	1.03	12.94		0.70	20.58
Sweetcorn							
- field operations				3.83			3.83
- fertilizer	5.74	1.33	1.11	0.25		0.64	9.07
- pesticides	0.59	0.03		0.54		0.19	1.35
	6.33	1.36	1.11	4.62		0.83	14.25
Lettuce							
- field operations				10.05			10.05
- fertilizer	6.31	1.46	1.24	0.28		0.64	10.00
- pesticides	0.59	0.07		1.08		0.34	2.08
	6.90	1.53	1.24	11.41		1.05	22.13
Onions							
- field operations				9.61			9.61
- fertilizer	8.83	2.34	1.64	0.40		0.75	13.96
- pesticides	1.59	0.34		4.62		0.84	7.39
	10.42	2.68	1.64	14.63		1.59	30.96
Peas							
- field operations			2.75	2.21			4.96
- fertilizer	1.30	0.47	0.49	0.12		0.21	2.59
- pesticides	0.04	0.02		0.18		0.02	0.26
	1.34	0.49	3.24	2.51		0.23	7.81
Potatoes							
- field operations			15.21				15.21
- fertilizer	9.25	2.25	1.97	0.55		0.99	15.01
- pesticides	0.99	0.07		1.01		0.33	2.40
	10.24	2.32	17.18	1.56		1.32	32.62

APPENDIX D (cont.)

Energy costs for crop production, 1978 ($ per acre)

CROP	Nat. Gas	Fuel Oil	Diesel Fuel	Gasoline	Propane	Electricity	Total
Rutabagas							
- field operations			5.29	2.48			7.77
- fertilizer	3.07	1.38	1.70	0.27		0.84	7.26
- pesticides	1.00	0.17		1.63		0.47	3.27
	4.07	1.55	6.99	4.38		1.31	18.30
Tomatoes-fresh							
- field operations				8.24			8.24
- fertilizer	10.30	2.79	2.60	0.51		1.41	17.61
- pesticides	1.20	0.17		1.57		0.40	3.34
	11.50	2.96	2.60	10.32		1.81	29.19
Tomatoes-processing							
- field operations				8.24			8.24
- fertilizer	4.38	2.73	3.15	0.46		1.30	12.02
- pesticides	1.20	0.17		1.57		0.40	3.34
	5.58	2.90	3.15	10.27		1.70	23.60

NOTE: Excludes energy costs for crop transportation.

APPENDIX E

Assumptions on transportation of crops

Energy consumption figures are for delivery to first destination, not to ultimate user.

Grain corn

Haul to dryers or elevators or feed mills by gasoline powered tandem-axle truck.
Round trip distance = 25 miles.
Payload = 16 tons.
Based on March 1978 report 17.2 gallons/1000 bushels.
Therefore, per acre 85/1000 x 17.2 = 1.5 gal. gasoline/acre.

Wheat, barley, oats, mixed grains

Round trip distance = 14 miles.
Payload = 18 tons.
Based on March 1978 report 18.8 gallons/1000 bushels.
53/1000 x 18.8 = 1.0 gal. gasoline/acre.

White beans

Distance and payloads as per wheat, 12.5 gal./1000 bushels.
24/1000 x 12.5 = 0.3 gal. gasoline/acre.

Soybeans

As per wheat, and assuming 30 bu./acre.
30/1000 x 18.8 = 0.5 gal. gasoline/acre.

Peaches, apples, grapes

(i) 250, 6 quart baskets via pick-up truck, 100 miles round-trip from Peninsula to Toronto terminal. 100 miles/12 m.p.g. = 8.3 gal. gasoline per (2500-3000 lbs.) payload, therefore 3 gal. gasoline per 1000 lbs.

(ii) processing apples
- 20 ton payload, 150 mile round-trip, 5 m.p.g. diesel tractor. 0.75 gal. diesel per 1000 lbs.

(iii) some fruit is sold at farm gate or at adjacent road-side stand. Typical average = (1.5 gal. gasoline + 0.4 gal. diesel)/1000 lbs.

Cabbage, cauliflower, celery, onions, peas, tomatoes, cucumbers, carrots

Round trip distance = 100 miles.
Payload (average) = 5 tons
5 m.p.g. gasoline, 8 m.p.g. diesel.
Assume 75% of trucks are gasoline-powered.
(1.5 gal. gasoline + 0.3 gal diesel)/1000 lbs.

Potatoes, rutabagas

Round trip distance = 150 miles
Payload (average) = 10 tons.
4 m.p.g. gasoline, 6 m.p.g. diesel.
(0.9 gas. gasoline + 0.6 gal. diesel)/1000 lbs.

APPENDIX F

Energy consumption for animal production, 1978 (MJ)

LIVESTOCK TYPE	Natural Gas	Fuel Oil	Diesel Fuel	Gasoline	Propane	Electricity
Dairy cows: per cow per annum						
- housing, manure handling, feed preparation			1050			2267
Cattle: per annum						
- housing and manure handling			350			237
- feed preparation (incl. manufactured feeds)	63	31	70	17		25
Total	63	31	420	17		263
Cow-calf: per cow per annum						
-housing, manure handling, feed preparation			350			169
Feeder hogs: per finished hog						
- housing, manure handling, feed preparation			52		0.15	216
- manufactured feed	25	16	18	7		11
Total	25	16	70	7	0.15	227
Sheep: per ewe per annum						
- housing, manure handling, feed preparation			35			32
Layer hens: per 100 birds per annum						
- housing and manure handling	316	283	35		3.0	2231
- manufactured feeds	1456	786	1401	438		576
Total	1772	1068	1436	438	3.0	2807
Chicken broilers: per 1000 birds						
- housing and manure handling	3165	2829	0.2		30.0	2159
- manufactured feeds	1393	700	7.5	350		540
Total	4557	3529	7.7	350	30.0	2699
Chicken roasters: per 1000 birds						
- housing and manure handling	3165	2829	0.2		30.0	2159
- manufactured feeds	2563	1257	14.0	700		1008
Total	5728	4087	14.2	700	30.0	3167
Turkey broilers: per 100 birds						
- housing and manure handling	422		0.2		17.0	756
- manufactured feeds	389	204	2.2	123		154
Total	855	204	2.4	123	17.0	910
Heavy turkeys:per 100 birds						
- housing and manure handling	422		0.2		17.0	756
- manufactured feeds	1049	519	5.8	280		417
Total	1471	519	6.0	280	17.0	1173

Source: Research Report 1

APPENDIX G

Total energy consumption and cost for animal production, 1978

Livestock Type and Quantity		Natural Gas TJ	Natural Gas $000	Fuel Oil TJ	Fuel Oil $000	Diesel Fuel TJ	Diesel Fuel $000	Gasoline TJ	Gasoline $000	Propane TJ	Propane $000	Electricity TJ	Electricity $000
Dairy cows:	618 000					649	2484					1340	12487
Cattle:	1 422 000	90	208	50	133	585	2428	22	135			374	3177
Cow-calf:	430 000					151	576					72	642
Feeder Hogs:	2 178 000	55	127	18	102	172	748	14	83	40	154	492	4303
Sheep:	83 000						11					3	32
Layer hens:	8 214 000	138	343	97	279	3	616	32	195	30	116	230	1852
Chicken broilers:	63 758 000	297	713	246	786	85	449	20	121	236	899	173	1386
Chicken roasters:	15 785 000	91	219	72	224	39	205	9	60	58	222	51	377
Turkey broilers:	12 069 000	98	237	27	74	51	260	13	80	253	764	112	899
Heavy turkeys:	6 957 000	102	243	73	108	66	380	17	106	146	556	82	602
TOTAL		871	2090	583	1706	1801	8157	126	780	764	2911	2990	25757

NOTE: Livestock transportation excluded

SOURCE: Research Report 1

APPENDIX H

Determination of energy costs as percentage of production costs (from Research Report 1)

SHEEP PRODUCTION

1978 Energy Consumption and Costs (per ewe, per year)

Consumption			Cost ($)
Diesel fuel	0.2 gallons		0.13
Electricity	9 kWh		0.29
		Total	$0.42

Costs of Production

Essential material inputs	$68.20
Energy costs as percentage of essential material input costs	0.6%
Total production costs	$83.47
Energy costs as percentage of total production costs	0.5%

NOTE: Energy consumed by lambs and rams included with ewe costs.

BEEF PRODUCTION

1978 Energy Consumption and Costs (per finished steer)

Consumption		Cost ($)
Natural gas	60 $ft.^3$	0.15
Fuel oil	0.2 gallons	0.09
Diesel fuel	2.4 gallons	2.11
Gasoline	0.1 gallons	0.09
Electricity	73 kWh	2.23
	Total	$4.67

Costs of Production

Essential material inputs	$169.03
Energy costs as percentage of essential material input costs	2.8%
Total production costs	$210.48
Energy costs as percentage of total production costs	2.2%

NOTE: Average feedlot production equal to 408 finished steers per annum, average gain equal to 417 lb. per head.
Cost of calf not included with expenses since beginning inventory is subtracted from ending inventory for income and expense determination; average 1977 price paid per calf = $286, average 1978 price paid per calf = $487.

MILK PRODUCTION

1978 Energy Consumption (per cow)

Consumption		Cost ($)
Diesel fuel	6 gallons	4.02
Electricity	630 kWh	20.22
	Total	$24.24

Costs of production

Essential material inputs	$324.32
Energy costs as percentage of essential material input costs	7.5%
Total production costs	$568.39
Energy costs as percentage of total production costs	4.3%

NOTE: Cost of production per cow, assuming milk production of 8,187 lb. per annum.

EGG PRODUCTION

1978 Energy Consumption and Costs (per 100 birds per annum)

Consumption		Cost ($)
Natural gas	1680 ft.^{3}	4.18
Fuel oil	6.8 gallons	3.39
Diesel fuel	8.2 gallons	7.51
Gasoline	2.5 gallons	2.37
Propane	3.0 gallons	1.41
Electricity	780 kWh	22.54
	Total	$41.40

Cost of production (2000 dozen eggs)

Essential material inputs	$880
Energy costs as percentage of essential material input costs	4.7%
Total production costs	$1 364.20
Energy costs as percentage of total production costs	3.0%

PORK PRODUCTION

1978 Energy Consumption and Costs (per finished hog)

Consumption		Cost ($)
Natural gas	24 ft.^{3}	0.06
Fuel oil	0.1 gallons	0.05
Diesel fuel	0.45 gallons	0.34
Gasoline	0.04 gallons	0.04
Propane	0.15 gallons	0.07
Electricity	63 kWh	1.97
	Total	$2.53

Costs of Production

Essential material inputs	$102.05
Energy costs as percentage of essential material input costs	2.5%
Total production costs	$122.75
Energy costs as percentage of total production costs	2.1%

NOTE: Energy overhead for sow and boar is included.

BROILER CHICKENS

1978 Energy Consumption and Costs (per 100 birds)

Consumption		Cost ($)
Natural gas	4320 ft.^{3}	7.95
Fuel oil	22.0 gallons	12.32
Diesel fuel	7.7 gallons	7.03
Gasoline	2.0 gallons	1.90
Propane	30.0 gallons	14.10
Electricity	750 kWh	21.73
	Total	$65.03

Costs of production (1000-3.7 lb. broilers)

Essential material inputs	$1 106.30
Energy costs as percentage of essential material input costs	5.9%
Total production costs	$1 419.32
Energy costs as percentage of total production costs	4.6%

NOTE: Cost of production for 3.7 lb. bird, 2.15 feed conversion, quota period #54 - week ending Dec. 23, 1978.

TURKEY BROILER PRODUCTION

1978 Energy Consumption and Costs (per 100 birds)

Consumption		Cost ($)
Natural gas	769 $ft.^3$	1.96
Fuel oil	1.3 gallons	0.61
Diesel fuel	2.4 gallons	2.16
Gasoline	0.7 gallons	0.67
Propane	17 gallons	7.66
Electricity	253 kWh	7.45
	Total	$20.84 *

Cost of Production (100-10 5 lb. broilers)

Essential material inputs	$424.00
Energy costs as percentage of essential material input costs	4.9%
Total production costs	$477.00
Energy costs as percentage of total production costs	4.4%

NOTE: The Ontario Turkey Producer's Marketing Board indicates approximately $22.80 per 100 birds for energy used (on farm only) compared with $15.92 per 100 birds (on-farm only) according to the data base used in this report. $22.80 (on-farm) + $4.92 (manufactured feed energy use) = $27.72 and represents 6.5 per cent and 5.8 per cent of E.M.I. and total production costs respectively.

HEAVY TURKEY PRODUCTION

1978 Energy Consumption and Costs (per 100 birds)

Consumption		Cost ($)
Natural gas	1395 ft^3	3.50
Fuel oil	3.3 gallons	1.55
Diesel fuel	6.0 gallons	5.47
Gasoline	1.6 gallons	1.52
Propane	17 gallons	7.99
Electricity	326 kWh	8.65
	Total	$28.68 *

Costs of Production (100-21 lb. avg. wt turkeys)

Essential material inputs	$837.00
Energy costs as percentage of essential material input costs	3.4%
Total production costs	$957.00
Energy costs as percentage of total production costs	3.0%

Note: The Ontario Turkey Producers' Marketing Board indicates approximately $22.47 per 100 birds for energy used (on farm only) compared with $15.92 per 100 birds (on farm only) according to the data base used in this report. $22.47 (on farm) + $12.76 (manufactured feed energy use) = $35.23 and represents 4.2% and 3.7% of E.M.I. and total production costs respectively.

APPENDIX I

Projected Increases in Crop and Livestock Output

Crop production - Ontario - area requirement

Crop	Area (10^3 Acres)					Projected Area (10^3 Acres)	
	1976	1977	1978	1979	AVG.	1985	2000
Barley, mixed grains	1,197	1,130	1,170	1,125	1,155	1,230	1,446
Oats	545	450	445	405	461	491	577
Winter wheat ,rye	573	631	380	549	533	566	667
Grain corn	1,580	1,610	1,680	1,870	1,685	1,734	1,843
Silage corn	864	865	840	810	845	869	924
Soybeans	378	550	705	700	583	615	705
White beans	150	160	148	84	135	142	161
Haylage, hay	2,851	2,745	2,850	2,820	2,817	3,042	3,701
Pasture	1,837	1,755	1,670	1,590	1,713	1,850	2,251
Apples	24	24	24	25	24	25	27
Grapes, peaches	33	35	34	35	34	35	38
12 veg. crops	162	156	159	164	160	166	181
Total	10,194	10,111	10,105	10,177	10,145	10,765	12,521

Note: Projected area employs 4 year average as base year, and assumes the following:

(i) % increase in total output, per annum

	1981-6	1987-91	1992-96	1997-2001
Corn	1.56	1.46	1.27	1.12
Grains	"	"	"	"
Forage crops	"	"	"	"
Soybeans	"	"	"	"
White beans	1.06	0.96	0.77	0.62
Fruits	"	"	"	"
Vegetables	"	"	"	"

(ii) % increase in yield per acre, per annum

	1981-6	1987-91	1992-96	1997-2001
Corn	1.0	1.0	1.0	1.0
Soybeans	0.5	0.5	1.0	0.5
Grains	0.3	0.3	0.3	0.3
Forage, W. Beans	0.0	0.0	0.0	0.0

(iii) Total output increase required	1985	2000
Corn, grains, forage crops, soybeans	8.0%	31.4%
White beans, fruits and vegetables	5.4%	19.0%

(iv) Total projected productivity increase:	1985	2000
Corn	5.1%	22.0%
Soybeans	2.5%	10.5%
Grains, cash crops	1.5%	6.2%
Forage crops, white beans	0.0%	0.0%

(v) Projected area increase required:	1985	2000
Corn	2.9%	9.4%
Soybeans	5.5%	20.9%
Grains	6.5%	25.2%
Forage crops	8.0%	31.4%
White beans	5.4%	19.0%
Fruit and vegetable crops	3.9%	12.9%

Livestock production - Ontario - annual quantities

Livestock Type	Quantity	Projected Quantity	
	1978	1985	2000
Dairy cows	618,000	635,900	670,500
Cattle	1,422,000	1,463,000	1,543,000
Cow-calf pairs	430,000	442,000	468,000
Feeder hogs*	2,625,000*	2,769,000	3,174,000
Sheep (ewes)	83,000	87,000	100,000
Layer hens	8,214,000	8,452,000	8,912,000
Chicken broilers*	63,758,000	65,607,000	69,177,000
Turkey broilers*	12,069,000	12,419,000	13,095,000
Heavy turkeys*	6,957,000	7,159,000	7,548,000

* = 1979 data used, since pork production is increasing sharply, with marketings for first 8 months of 1980 being 20% greater than for same period in 1979.

Note: Projected quantity employs 1978 as base year, and starting in 1981 assumes the following:

(i) % increase in total output per annum

	1981-6	1987-91	1992-96	1997-2001
Poultry, milk, beef	1.06	0.96	0.77	0.62
Hogs	1.56	1.46	1.27	1.12

(ii) % increase in yield per animal, per annum

	1981-6	1987-91	1992-96	1997-2001
All species	0.5	0.5	0.5	0.5

(iii) Total output increase required:	1985	2000
Poultry, milk, beef	5.4%	19.0%
Hogs	8.0%	31.4%

(iv) Total projected productivity increase:	1985	2000
All livestock	2.5%	10.5%

(v) Projected increase in livestock numbers: (subtracting (iv) from (iii)	1985	2000
Poultry, milk, beef	2.9%	8.5%
Hogs	5.5%	20.9%

APPENDIX J

Summary of the projected effects of conservation (and improved efficiencies) on the agricultural production system

Activity	Reduction in energy requirements (%)	
	1985	2000
Animal production (per animal)		
Dairy, beef, and sheep		
- electricity	12	30
- diesel	4	15
Hogs		
- electricity	12	48
- heating fuels	12	45
Poultry		
- electricity	9	30
- heating fuels	13	44
Crop production (per acre)	10	35
Transportation - trucks (per unit delivered)	20	50

NOTE: This summary is based on the conservation scenario in Research Report 3. 1978 is the base year.

APPENDIX K

Transportation energy costs of animal commodities, low-price and high-price scenarios, 1985 (current dollars)

	Fuel consumption (litres) (diesel + gasoline)	Cost ($)		Sum of costs of production and transportation energy ($)		Transportation energy cost as percentage of sum (%)	
		Low-price	High-price	Low-price	High-price	Low-price	High-price
Milk	2.81 + 13.6 (per 3927 kg milk)	8.44	9.13	52.74	54.13	16.0	16.9
Beef	6.17 + 5.81 (per slaughter animal)	6.20	6.77	14.78	15.83	41.9	42.8
Pork	0.36 + 1.09 (per finished hog)	0.75	0.93	5.41	5.60	13.9	16.6
Eggs (and fowl)	90.8 (2000 dozen eggs + 100 fowl)	47.00	50.60	126.84	134.38	37.1	37.7
Poultry: Chicken broilers	21.8 (per 1000 birds)	11.28	17.48	149.61	159.87	7.5	10.9
: Turkey broilers	58.1 (per 1000 birds)	30.08	33.28	446.88	471.98	6.7	7.1
: Heavy turkeys	98.1 (per 1000 birds)	50.76	56.16	616.86	658.36	8.2	8.5

SOURCE: Research Report 1, Table IV 4:2 (A)

APPENDIX L

Transportation energy costs of animal commodities, low-price and high-price scenarios, 2000 (current dollars)

	Fuel consumption (litres) (diesel + gasoline)	Cost ($)		Sum of costs of production and transportation energy ($)		Transportation energy cost as percentage of sum (%)	
		Low-price	High-price	Low-price	High-price	Low-price	High-price
Milk	2.0 + 9.5 (per 4436 kg milk)	21.50	23.10	124.28	141.08	17.3	16.4
Beef	3.9 + 3.6 (per slaughter animal)	13.98	15.10	37.00	41.00	37.8	36.8
Pork	0.23 + 0.68 (per finished hog)	1.69	1.82	10.82	12.32	15.6	14.8
Eggs (and fowl)	56.8 (2000 dozen eggs + 100 fowl)	105.87	113.10	296.93	332.65	35.7	34.0
Poultry: Chicken broilers	13.6 (per 1000 birds)	25.41	27.15	360.28	411.84	7.1	6.6
: Turkey broilers	36.3 (per 1000 birds)	67.76	72.40	1053.46	1210.10	6.4	6.0
: Heavy turkeys	61.2 (per 1000 birds)	114.35	122.17	1543.35	1763.98	7.4	6.9

SOURCE: Research Report 1, Table IV 2 (B)

APPENDIX M

Table 1

Trucking productivity: future power plants and their impacts

Engine type	Application	Engine efficiency improvement over gasoline engine (%)	Comments
Modified gasoline engine			
1) Lean burn - reduce fuel to air mixture ratio	- light to medium duty trucks	5-10	- currently under test in passenger cars
2) Fuel injection - careful monitoring of fuel-air mixture	- all vehicles	0-5	- well proven in high-powered autos
3) Turbocharging - uses exhaust gases to drive air compressor to generate more air for combustion	- effective for short and long haul	10-20	- increases output of engine so smaller engine can deliver power of a large one
4) Stratified charge - combustion takes place in two stages and allows lean mixture	- all vehicles	5-10	- tested in trucks and used in some autos
Electric power	- short range pickup and delivery	10-20	- slow development of battery technology suggests limited application before 1990
Diesel engine			
1) Dieselization with current technology	- all vehicles	20-40	- extensive use now in heavy large vehicles, light duty will be developed by 1980
2) Improved diesel engines, improved torque curves and turbocharging	- short and long haul	10-20 (over regular non-turbocharged diesels)	- under development

* Improvement over gas engine

SOURCE: Interagency Study of Post 1980 Goals for Commercial Motor Vehicles - U.S. DOT and various technical articles.

Table 2

Trucking productivity: non-engine technological improvements

Improvement	Pickup and delivery operations	Intercity operations	Comments
1) Lubricants (decrease drive train friction losses)	1-2% improvement in efficiency	1-3% improvement	Used in engine and drive line
2) Engine accessories (temperature-controlled cooling fans)	3-6% increase in economy	5-8% increase in economy	
3) Radial tires	3-5%	6-10%	
4) Automatic transmission	3-5%		Applies only to local operations
5) Improved aerodynamics		7-12%	Primarily add on devices at low end and redesign at high end
6) Matching transmission and drivelines to needs		2-5%	
7) Reduction in tare	2-5%	5-7%	10% reduction in tare is possible by 1985

SOURCE: See previous table.

APPENDIX M

Table 3

Train energy conservation opportunities

	Potential saving (%)
Operational opportunities	
Reduce locomotive idling	4
Reduce fuel spillage	0.5
Improve train handling	1
Improve consist makeup	1
Reduce operating speeds	1-5
Increase net-to-gross shipping ratio	?
Technological opportunities	
Streamlining	2
Reduce tare weight of cars	1-6
Locomotive improvements	3-5
Steerable trucks	2
Infrastructure improvements	
Concrete ties	1
Gradient modifications	?
Double tracking	?
Total potential	16-28

SOURCE: Canadian Institute for Guided Ground Transportation, 'Canadian railway energy conservation and alternative fuels,' 78-13, Queen's University.

APPENDIX N

Table 1

Annual on-farm methane production potential (per farm)

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1. Methane calculations: a) as per lab handout (Biomass Inst.)

   b) based on collectable manure

Swine and poultry:	100% collectable
Beef and dairy:	on feedlot: 100%
Beef and dairy:	on pasture: 50%

   c) biogas analysis 65% CH_4

   d) no debit for digestor heat

2. Manure calculations: a) Amount of manure production taken from computer printout.

Dairy	60 lb/day - L.E.
Swine	65
Beef	60
Poultry(layers)	53 - used this one for all
(broilers)	71

APPENDIX N

Table 2

Ontario manure production

	Number (OMAF'79)	Avg. wt. (lb) (OMAF)	Livestock equivalents	Raw manure lb/day-LE (ASAE)	Production total (x10^6lb/day)	Total (x10^6lb/day)	Collectable fraction (intergroup)	Total collectable (x10^6lb/yr)
Bulls	35 000	1 500	52 500	60	3.15	1 150	0.20	230
Dairy cows	525 000	1 200	630 000	82	51.66	18 856	0.50	9 428
Dairy heifers	245 000	500	122 500	85	10.41	3 800	0.50	1 900
Beef cows	395 000	1 200	474 000	60	28.44	10 380	0.20	2 076
Beef heifers	425 000	500	212 500	90	19.12	6 980	0.75	5 235
Steers	740 000	1 000	740 000	60	44.4	16 210	0.75	12 158
Calves	570 000	250	142 500	60	8.55	3 120	0.20	624
Sows & boars	415 000	400	166 000	50	8.30	3 030	0.90	2 727
Other pigs	978 000	100	97 800	65	6.36	2 320	0.90	2 088
Poultry								
Laying hens	8 888 000	4	35 552	53	1.88	688	1.00	688
Chicks & pullets	4 445 000	2	8 890	53	0.471	172	1.00	172
Broilers, etc.	20 300 000	4	81 200	71	5.76	2 102	1.00	2 102
Turkeys	4 308 000	9	38 772	71*	2.75	1 005	1.00	1 005
						69 813		40 433

*assume same as broilers

APPENDIX N

Table 3

Ontario manure production

	Total produced (raw feces & urine) $(10^6$lb/yr)	Total collectable	
		$(10^6$lb/yr)	$(10^3$tons/yr)
Dairy - Cows & Heifers	22 656	11 328	5 664
Cattle - Bulls			
- Beef Cows & Heifers			
- Steers			
- Calves	37 840	20 323	10 161
Swine - Sows & Boars			
- All Others	5 350	4 815	2 407
Poultry - Layers			
- Broilers			
- Chicks & Pullets	2 962	2 962	1 481
- Turkeys	1 005	1 005	502
	69 813	40 433	20 215

NOTE: Collectable fraction: dairy 0.5, beef cows & calves 0.2, beef heifers & steers 0.75, swine 0.9, poultry 1.0

APPENDIX N

Table 4

Methane production from manure

		Livestock equivalent (x 1000 lb)	Collectable[1] manure fraction	Biogas Production[2] (ft^3/day-LE)	mmcf/year	10^6 (BTU/yr)[3]
Dairy	- cows					
	- heifers	752 500	0.50	52.67	7 233	4 702 000
Cattle	- bulls					
	- cows					
	- calves	669 000	0.20	42.72	2 086	1 356 000
	- heifers					
	- steers	952 500	0.75	42.72	11 133	7 237 000
Swine	- sows & boars					
	- others	263 800	0.90	42.01	3 640	2 366 000
Poultry	- layers					
	- chicks, pullets	44 442	1.0	99.73	1 617	1 051 000
	- broilers, etc	81 200	1.0	133.6	3 950	2 567 000
						19 279 000

NOTE:
1. 'Liquid Fuels from Renewable Resources Feasibility Study'. Intergroup Consulting Economics Ltd. March 1978
2. Lapp estimated on the basis of 17.5 ft^3 of biogas per lb of volatile solids destroyed
3. Assumes biogas analysis of 65 per cent CH_4; 35 per cent CO_2; calorific value 650 BTU/ft^3

APPENDIX N

Table 5

Methane - biogas (No of 1000 lb. livestock equivalents to produce 1 million BTU of heat energy, depending on gas storage capacity)

Livestock type	Rate of gas production ($\frac{\text{BTU}}{\text{day - LE}}$)	Storage capacity* (mcf) (days of gas production)			
		1.5 mcf 1 day	10.78 7	21.53 14	23.1 15
Hog	27 300	36.6	5.23		2.44
Dairy	34 240	29.2	4.17	2.08	1.95
Beef	27 768	36.0	5.14	2.57	2.4
Poultry					
- boilers	86 840	11.5	1.64	0.82	0.77
- layers	64 820	15.4	2.2	1.1	1.03

* 1 million BTU biogas at 65% CH_4; 35% CO_2 = 10^6 BTU / 650 BTU/ft^3
= 1 538 ft^3
= 1.54 mcf

APPENDIX N

Table 6

Sludge nutrient content associated with 10^6 BTU biogas production

Livestock type	# L.E.	Amount of Manure per L.E.	% N	Potential amount of nitrogen in digested sludge (lb)
Hogs	36.6	65	0.67	1 435
Dairy	29.2	82	0.47	1 038
Beef	36.0	60	0.5	972
Poultry				
- boilers	11.5	71	4.0	2 939
- layers	15.4	53	1.2	979

NOTE: 1.54 mcf biogas; 10 per cent loss of N

ENERGY INVESTMENTS

Digester heating requirement may be up to 45 per cent[1] of the biogas energy content. If this heat is to be supplied by the product gas, increase the number of livestock required by 100 - 55 = 1.82 to yield the same net product.

If the heat is to be provided by solar, provide 10^6 BTU x 0.45 / 410 BTU/ft^2 - day = 1098 ft^2 of collectors for typical January day digester heating.

Digester electricity requirements may be 9 per cent of the biogas energy content.[2]

SOURCE: 1. Biomass Energy Institute 'Biogas production from animal manure,' Winnipeg, March 1978.

2. Bailie, W. Virginia, 'Technical and economic assessment of methods for direct conversion of agricultural residue to usable energy,' October 1976.

APPENDIX O

Table 1

Straw production estimates (conservative estimate)

Assumption: straw (tons) to grain (bu.) ratios.

Wheat	0.0375	Flaxseed	0.0420
Oats	0.0213	Rapeseed	0.0500
Barley	0.0240	Mix grass	0.0118
Rye	0.0560	Grain corn	0.0280
		Faba beans	0.0560

Estimated straw production 1979

	Production	Straw yield ('000 tons)
Wheat	26 179 000 bu.	981.7
Oats	23 272 000 bu.	495.7
Barley	18 998 000 bu.	455.9
Mixed grains	49 532 000 bu.	584.5
Rye	1 950 000 bu.	109.2
Buckwheat (assume as wheat)	240 000 bu.	9.0
Grain corn	169 202 000 bu.	4,378.0
Flaxseed	225 000 bu.	9.45
Dry white beans (at 60 lb./bu., assume as faba beans.)	1 359 000 cwt	126.8
		7,150.3 x 10^3Tons

(cf. Intergroup estimate, based on 3 yr. avg. (1974-76): 5 581 x 10^3Tons)

APPENDIX O

Table 2

Availability of straw in Ontario

- Straw produced		7 150 000 tons
- Straw left on field (=1/3 x total)	2.387 x 10^6tons	
- Straw required for wintering Cattle (=0.6 ton/animal) (2 900 000 cattle, incl. calves)	1.74 x 10^6 tons	
Total not available:	4.12 x 10^6 tons	
- Straw available:		3.03 x 10^6 tons

(cf. Intergroup: 2.206 x 10^6tons)

NOTE:
- greatest straw & stover concentrated in: Middlesex, Elgin, Essex, Kent, Lambton, Oxford counties.
- leave 1/2 on field

APPENDIX O

Table 3

Forage production (million tons)

	3 yr. avg. (1974-76)	1979
Tame hay	6.514	7.849
Fodder corn	9.341	9.945

APPENDIX O

Table 4

Specially grown biomass feedstocks

Crop	Yield	Cost of delivery to central plant ($/tonne)
Faba beans	1.0 - 1.25 tons seed/acre (14% MC)	
	3-5 tons silage/acre Nitrogen fixing	29
High-Yield	1.8 - 3.0 T/acre	60
Wheat straw		22
Sweet clover	1.5 - 3.0 T/acre (10% MC)	49
Barley	0.9 - 3.5 T/acre	
Sugar beets	3 T tubers/acre	
	1-2 T tops/acre	
Jerusalem artichokes	4 T tubers/acre 3-4 T tops/acre	
Rye & corn	7.9 T/acre	

APPENDIX P

Table 1

Gasification - feedstock required to produce 10^6 BTU of producer gas

Feedstock Type	Energy content (BTU/lb)	Hot gas product[1] feedstock requirement (lb)	Agricultural[2] requirement	Cold, clean gas product[1] feedstock requirement (lb)	Agricultural[2] requirement	Feedstock collection[3] energy requirement (BTU)
Straw	6550	180	0.09 a. grain	218	0.11 a. grain	11 000
Stover	7540	156	0.031 a. corn	189	0.038 a. corn	14 000
Corn cobs	8150	145		175		
Wood chips	8810	112	0.056 a. woodlot	135	0.0675 a. woodlot	

NOTE: 1 Energy content of gas from agricultural residue = 140-160 BTU/ft^3,
assume 150 BTU/ft^3
Energy content of gas from wood chips = 170-190 BTU/ft^3,
assume 180 BTU/ft^3
Conversion efficiency:
crop residue to hot gas = 85-90%, assume 85%
crop residue to cold, clean gas = 65-75%, assume 70%

2 Straw yield = 1.0 T/acre
Stover yield = 2.52
Wood = 0.5-1.0 T/acre-year

3 Straw: 0.123 MM BTU/a.
Stover: 0.362 MM BTU/a.

APPENDIX P

Table 2

Pyrolysis - feedstock required to produce 10^6 BTU of gas and char

Feedstock type (10% M.C.)	Conversion rate[1] BTU / lb. feedstock	Feedstock requirement (Ton)	Land[2] requirement (acre)	Feedstock collection energy requirement (BTU)[3]	Feedstock drying requirement (BTU)
Corn stover	4730	0.106	0.0402	14 000	190 000
Straw	4730	0.106	0.106	13 000	190 000

1. SBRG. 'Pyrolysis of agricultural biomas as a source of fuels for Canadian farm operations, 5 July 1979'
2. Stover yield = 2.52 T/a, straw = 1.0 T/a
3. Straw: 0.75 gal./a = 0.75 gal./T; 0.123 MM BTU/t
   Stover: 2.2 gal./a = 0.362 MM BTU/a.

NOTE: To dry 40% M.C. feedstock to 10% requires removing 0.6 lb H_2O at 1,500 BTU/lb. H_2O = 900 BTU/lb. feedstock.
Caloric value of products: gas 322-376 BTU/ft^3; 300-500 BTU/ft^3
char 10 300 BTU/lb - 12 000 BTU/lb
(i.e. equivalent to coal)

APPENDIX P

Table 3

Economic evaluation - gasification

	Source	Project Description	Costs
1.	Stout. ASAE (1980)	Diamond Sunsweet, California input: 1 T/hr walnut shells = 16x10^{6}BTU/hr (approx.) output: 8,500 lb/hr, 15 psi steam = 8.24x10^{6}BTU/hr (approx.) yearly output = 85 000x10^{6}BTU	. capital cost = $126,00 . annual cost for capital, operating exp., and residue disposal = $62,000 US energy cost = $0.73/10^{6}BTU
	Hodam & Williams (1978)	estimate	capital cost $75 - 150,000 depending on unit size
2.	Hydro-Quebec (1979)	feasibility study a) gasification of straw-Western Canada	collection of feedstock $18.75/tonne gasification 20. $38.75/tonne = $68/10^{6}BTU + feedstock preparation and burner modification $20.00/tonne
		b) gasification of stover, Quebec	collection of feedstock + 10 mile transport $11.00/tonne 20 $21/tonne = 37/10^{6}BTU
	Biomass Corp.	359,000 BTU/hr. gasifier	$161,000 (US)
	Duvant Ltée (Quebec)	129,000 BTU/hr. gasifier 339,000 BTU/hr. gasifier	60,000 93,000
	Mellenger	339,000 BTU/hr. gasifier	$ 48,000

APPENDIX Q

ENERGY CONVERSION TECHNOLOGIES

Direct combustion

Direct combustion is the oldest and most common method of producing heat. The process involves the direct burning of a material in an excess of air; suitable feedstocks are those containing large quantities of cellulose, such as wood or solid waste.

This method is used in the forest products industry where hog fuel (bark, branches, etc.) and spent kraft mill liquors are burned to produce steam or even electricity. Most commonly the feedstock is burned in large conventional boilers with heat recovery in the form of steam. Steam so generated, however, may also be used to produce electricity in turbines and pass through exchangers to produce hot water which can be used in industrial processing or for heating purposes. The efficiency conversion rate for direct combustion is considered to be 80-90 per cent.

Although cellulosic agricultural residues could also be used to fuel furnaces, several factors make it an undesirable feedstock for this process: the low energy content of agricultural residues, the large quantities of feedstock required, and the fact that valuable by-products, which could be produced by other conversion technologies, would be lost through this process.

Hydrolysis

There are, in effect, three hydrolysis processes for the conversion of biomass to energy fuels: acid, enzyme and acid/enzyme hydrolysis.

The total hydrolysis process involves several phases: pre-treatment, hydrolysis, fermentation, and distillation or dehydration. Different types of feedstocks can be fed into the process at various stages, depending on the particular requirements of the feedstock.

In the pre-treatment stage, the feedstock is chopped, crushed, or milled. Then water is added, and the resulting slurry is cooked to expose the starch molecules and cooled. One technology, at least, has a steam pre-treatment phase.

In the hydrolysis phase, commercially produced bacterial or fungal enzymes, or barley malt, are added, allowing the starch to hydrolyse to fermentable sugars.

During the fermentation phase, micro-organisms, usually yeast, produce ethanol anaerobically. Fermentation may be accomplished by the batch method or by the relatively new continuous method.

Ethanol is then separated from the water by flash distillation or rectification to produce 190 proof alcohol. A dehydration process is required to produce 200 proof anhydrous ethanol.

This technology allows all types of biomass to be converted to alcohol and valuable by-products. The by-products from grain-based alcohol production are the various forms of distillers' dried grain products that are used as animal feed. Valuable by-products from wood-based alcohol production include lignin, which is an adhesive, and a wood fibre which can be used as a cattle feed ingredient. Poplar leaves, separated before the process begins, contain high-quality protein, and research is being carried out on the possibilities for human consumption.

Gasification

Gasification is a process in which the reaction of hydrogen with a feedstock produces a gaseous fuel. This fuel contains hydrocarbons, hydrogen, carbon monoxide, carbon dioxide, and nitrogen, the exact composition depending on such factors as temperature, pressure, time, and the presence of a catalyst. The calorific value of this gas is 150 BTU/ft^3. By adding oxygen to the reaction instead of air, or by enriching with natural gas, the calorific value can be raised to 350 BTU/ft^3.

Various gasification technologies have been developed by different companies. Some of these processes are also suitable for methanol synthesis, since gasification is a first step in the methanol synthesis process. If gasification processes produce a gas with a high proportion of nitrogen, the gas is unsuitable for methanol production. This occurs when air is used in the reaction as an oxygen source. However, if oxygen is used the resulting gas may be further processed to produce methanol.

Of the various processes which have been developed utilizing biomass as a feedstock, the feedstock has generally been wood or wood waste in some form or municipal solid waste. The calorific value of the gas produced from these various processes ranges from a low of 99 BTU/ft^3 to 500 BTU/ft^3. With some processes a carbon char results as a by-product, which can be used for landfill or as a fuel to provide heat for further gasification. The overall conversion efficiency ranges from 40 per cent to about 75 per cent.

Methanol synthesis

Methanol production has the advantage over ethanol production that gasification and synthesis processes do not depend on a particular feedstock. As long as the feedstock can be gasified and the supply is cheap and plentiful, methanol can be produced at very competitive prices.

The primary biomass feedstocks for methanol production are forest residues, energy plantation wood, and crop residues where available. In methanol synthesis the feedstock is gasified to produce syngas. This syngas may be supplemented by methane from anerobic digestion.

The overall efficiency of production of methanol from biomass is about 38 per cent.

Anaerobic disgestion

Anaerobic digestion is a two-stage biological process in which organic matter such as manure and cellulose is broken down in the absence of oxygen. In the first stage, fats, carbohydrates, and proteins are converted, by the action of bacteria, to simple organic acids. During the second stage these acids are transformed to methane and carbon dioxide by another type of bacteria. Both groups of bacteria work simultaneously, and such factors as temperature and loading rate are controlled.

The normal composition of biogas from anerobic digesters ranges between 60 and 70 per cent methane, and the balance is mainly carbon dioxide. The presence of carbon dioxide has no harmful effects but does reduce the energy content to the range of 600-700 BTU/ft^3 and makes storage more expensive.

Pure methane is colourless, odourless, lighter than air, combustible, and explosive when mixed with air in proportions ranging from 5 to 15 per cent by volume. It burns with a blue flame and has an energy content of 1000 BTU/ft^3. Extreme caution must be taken in all areas of production, handling, storage, and transportation because of its explosive characteristics.

Methane can be further converted to methanol in the same process as syngas.

APPENDIX R

Some of the briefs presented to the Committee and summary of their main points.

Organization	Main Points
Canadian Federation of Agriculture	• Conserve petroleum fuels through elimination of waste and adoption of conserving technology.
	• Essential to define the potential of agricultural fuel crops from marginal lands, new crops and new systems.
	• A plan for transition from petroleum fuels is essential to free farmers from reliance on petroleum fuels for farm use.
	• Community scale organization for using farm sourced biomass is most economic (i.e. through co-operatives).
	• Studies and programs needed to: a) evaluate currently operative biomass installations b) develop audits of farm energy.
	• Biomass energy possibilities should be economically related to imported fuel costs. This creates powerful argument for government assistance.
	• Agricultural energy allocation should be of higher priority than business in general. Rationing scheme now envisaged should be more rigorous.
Canadian Seed Growers Association	• If rationing of fossil fuels is necessary, agriculture should have the highest priority.
	• More research is necessary on farm-based ethanol production, solar and wind energy systems, biological and cultural controls for pest management, and development of more pest resistant plant varieties in order to reduce dependence on petroleum fuels.
	• Government incentives essential for development of alternate energy sources.
Canadian Wildlife Federation	• Wildlife land lost to agriculture results in costs to farmers from erosion and flooding.
	• Agricultural use of chemicals takes a toll on wildlife.

Organization	Main Points
Conservation Council of Canada	• Scope of committee's work should be extended to all parts of food system.
	• Examine closely potential problems of using farm waste to manufacture fuel, such as erosion, loss of nutrients and loss of organic fraction.
	• Methanol from manure should be examined.
	• Hybrid poplar for methanol on marginal land should be examined.
	• Need for government funding on the farm demonstration projects for energy conservation and production.
	• Study role of outside influences on energy use, such as land use for development.
	• Education and programs for soil testing to discourage overuse of fertilizer.
	• Reversal of trend from small labour intensive farms to large chemically oriented ones could save energy.
Maple Syrup Producers' Association	• Fuel costs can exceed 20 per cent of the price received by the producer.
	• Availability of oil and gas a concern.
	• Cost of energy related inputs a concern.
	• Most energy related problems are short-term as prospective new processing technologies should reduce reliance on fossil fuels.
The Burley Tobacco Growers' Marketing Board	• Assure an adequate supply of fuel for agriculture.
	• Encourage development of alternate fuel sources.
	• Encourage use of diesel fuel.
	• Ensure fertilizer supplies remain adequate and reasonably priced.
	• Enlarge support programs in order to preserve and improve market conditions for Ontario produced agricultural products.

Organization	Main Points
Ontario Egg Producers' Marketing Board	. Agriculture should have a high priority in energy allocation procedures.
Ontario Greenhouse Vegetable Producers Marketing Board	. Recognize importance of waste heat sources for future production but are concerned with disruption that large-scale development could bring to the existing industry. . Energy use a concern. . Support acreage control of greenhouse industry.
The Royal Architectural Institute of Canada	. A plea for more functional buildings related to the natural surroundings; incorporating energy conservation through the use of the natural surroundings such as wind breaks from trees, angle of placement to the sun and abandonment of the sealed building.
The Ontario Rutabaga Producers' Marketing Board	. Educate farmers in the better use of crop rotation to reduce fertilizer consumption. . Educate farmers to reduce tillage. . Energy alternatives such as hydrogen rather than alcohol should be studied.
Ontario Soil and Crop Improvement Association	. Want assurances that other sectors of industry are under the same energy constraints as agriculture. . Conservation is possible in several areas and research is required a) New tillage techniques should be developed b) Improve fuel efficiency of tillage equipment c) Soil tests and timing of fertilizer applications d) Harvesting and storage system e) Herbicide and pesticide use f) Economic crop drying methods g) Crop rotation to save fertilizer. . Fertilizer prices not always based on cost but on what farmers will pay. Ontario government should have greater involvement with procedures and possible participation in production e.g., in Maritimes.

Organization	Main Points
	• Improve manure management.
	• Crops for energy only grown if a real energy shortage occurs or the price for feedstock is right.
	• Only a few farmers will be interested in ethanol/methanol processing.
Ontario Research Foundation	• No direct recommendation to the committee but generally supports energy conservation in agriculture.
Ontario Municipal Electric Association	• Rural areas should be encouraged to switch from oil to electricity through financial incentives
	• Rates for power district industrial users should be equalized with municipal industrial customers. Additional revenues could be used to reduce rural residential rates but without direct rate subsidy.
Ontario Trucking Association (Agricultural For-Hire Truck Operators)	• Truckers are the main carriers of agricultural inputs and outputs.
	• Agricultural energy allocation policies must include trucking.
	• Services requested of truckers not related to conserving fuel but to the price of the product. Hence specialized vehicles and express services that do not allow backhauls are common.
Fertilizer Institute of Ontario	• Fertilizer energy only about 2.8 per cent of total energy in the food system and about 15.4 per cent of farm gate energy.
	• Modern agriculture with energy inputs can have a solar energy capture efficiency 20 times greater than primitive agriculture.
	• Ontario uses about 1.2 per cent of total gas consumed to fulfill its nitrogen fertilizer requirements.
	• On the finite land base of Ontario maximum yields per acre are essential to minimize reliance on imports.

Organization	Main Points
	. Energy concerns of the fertilizer industry are - long term uninterrupted supply of natural gas; - gas is available at a competitive price. . Need for: a) Research into crop rotation to determine feasibility of natural nitrogen fixing. b) Efficient use of manures and sewage sludge. c) Crop residues for alternate energy with research to determine the effect on soil. d) Expansion of the use of waste heat in vegetable production and expansion of vegetable production to save transportation energy. e) Research on tillage practices. f) Solar energy in crop drying. g) Research to develop crops that produce their own nitrogen.
Flowers Canada Ontario Inc.	. Agricultural energy policy in Ontario will have a direct impact on the availability of product and the stability of the retail outlets. . Gas pricing is a disincentive to energy conservation (volume discounts). . Tax treatment of energy conservation in greenhouses is not helpful to conservation measures, e.g. tax on S.D.P. . Conservation, not alternative energy sources, important in dealing with energy in the short run. . Research should include crop production techniques, alternate crops and insect and disease control. . Waste heat must be fully commercially competitive and be combined with incentives to get growers to move. . To maintain a competitive industry the following is recommended:

Organization	Main Points
	- assure growers of constant energy supply; - long term loan interest loans for energy conserving materials and equipment; - when energy conservation acted on, fuel prices remain constant; - greenhouses be classified as agricultural structure; - change municipal by-laws to permit expansion; - imported energy conservation materials and equipment be free of import duties and, - all such products be free of sales tax; - research be directed to energy conservation, crop production and alternate crops; - greenhouses around waste heat facilities be developed on a dollar competitive basis; - establish a greenhouse energy advisory committee from Ministries of Agriculture and Energy.
Union Gas	. Natural gas should be made available for all purposes where economics permits and research should be directed to encouraging expanded application and use. . Higher prices for gas will ensure long term availability of supply. . Assistance to special groups such as greenhouse growers should be direct and not through the rates charged for gas. . Policies should be adopted to encourage efficient and effective usage.
Ontario Institute of Agrologists	. Agriculture and related industries should have top priority in case of fuel rationing. . Intensive research of alternative energy sources is necessary and their use in agriculture should be encouraged if it is economical. . Research of energy efficient countries or those using alternate sources should be made.

Organization	Main Points
	• The use of manure as a soil conditioner is more important than its use as biogas. Total use of crop residue as an energy source is not possible as it is required for soil management. • The Ontario government should subsidize and promote development of alcohol equipment. • Class 1 land should not be diverted to produce energy crops and the best of soil conservation techniques must be used on land used for such purposes. • Conservation in agriculture can be promoted in a number of ways including: - use of minimum and shallow tillage; - use of soil tests to determine precise fertilizer requirements; - use of erosion control measures to prevent loss of fertile soils; - harvesting of corn at proper maturity to reduce grain drying requirements.
Ontario Food Processors Association	• A number of objections to the energy allocation procedures in Bill C-42, namely classification of food processing industry in the manufacturing group. The manufacturing group should be separated into non-essential activities and those necessary for life; good processing should be in the latter category. • "Guaranteed-minimum" policy of gas companies should be amended. • The conservation record of a company should be taken into account in the event of energy rationing. • Government should consider incentives for conservation programs, especially in areas with long payback periods. • Environmental restrictions should not lead to use of more energy intensive techniques to conserve energy.

Organization	Main Points
Ontario Pork Producers Marketing Board	Endorsation of OIA resolutions concerning energy and agriculture in Ontario.
	Recommends establishment of committee in provincial government to oversee renewable energy projects.
	Recommends establishment of grants or loans to farmers interested in energy-saving or producing projects.
	Provide courses in this field to educate farmers.
Ontario Flue Cured Tobacco Growers' Marketing Board	Incentive assistance should be available to farmers to convert from oil to gas, including the cost of additional lines.
	Concern is expressed on the problem of obtaining present and future fuel supplies at a price which will not adversely affect farmers' competitive position.
	The tobacco industry should be given high priority in case of fuel rationing.
Ontario Milk Marketing Board	Expresses concern about the need to conserve petroleum fuels.
	Supports the position of the C.F.A. to the Energy Supply Allocation Board that agriculture has a special priority in energy allocation.
	Return to pre-modern farming methods which are not intensive is not advisable.
	The largest energy-savings in agriculture are to be made in the transportation, processing and home preparation sectors of the food system.
	Further study of alcohol production on farms (cost-benefit analysis) should precede costly investment by the farming community.
	Concern is expressed about the need to rationalize milk transport systems as a means of reducing energy consumption.
Ontario Federation of Agriculture	Fuel and energy related inputs must be available on a continuing basis at the critical periods for agriculture.
	Continue funding and monitoring of research projects on conservation.

Organization	Main Points
	• Make information on conservation ideas for farmers easily available. • Provide capital grants for manure storage facilities so that this material can be used to reduce fertilizer use. • Supports the idea of farm-scale ethanol stills but recommends that the provincial government urge the federal government to reduce bonding and license requirements. • The potential of alternate fuels such as alcohol and vegetable oils for farm machinery should be studied. • Pilot studies on methane projects for Ontario farms should be supported. • Farmers who co-generate electricity should be allowed to sell excess to Ontario Hydro. • Companies or municipalities who wish to establish composting facilities which will supply organic fertilizer should receive maximum support and co-operation. • Liaison between agriculture energy centre and OFA energy committee should be established.
National Farmers Union	• Private-market mechanisms should not be the sole determinant of energy developments and distribution. Petro-Can should assume this function. • To this end federal and provincial governments should: - nationalize the oil industry; - take measures to prevent drain of energy technology and expertise; - finance public research on alternate energy sources; - develop an all-Canadian energy grid; - provide a coordinated rail transportation policy; - insist on measures which will improve efficiency of internal combustion engines;

Organization	Main Points
	- ensure energy developments which are ecologically compatible and; - promote recycling of used petroleum products. . Recommends use of a two-price energy policy. Domestic price is to be based on the average Canadian retail price and the export price set at world levels. . A national energy fund should be established which has part of the domestic and export fuel price as its source of income. Its purpose would be to ensure research and development for self-sufficiency and on alternate energy sources. . An Institute of Energy Research should be established in Ontario to conduct research on alternate energy sources in agriculture and ways to improve energy efficiency in agriculture. . Supports Ontario government activities in the area of hydrogen research. . NFU expresses doubt about the practicality of ethanol as a fuel source due to feedstock constraints. More optimistic about the use of methanol as an alternative fuel, particularly for drying crops. . Methane is viewed as a promising on-farm energy source but farmers need more information in order to develop techniques. Development programs including incentives are necessary. . The Ontario government should develop an emergency fuel shortage plan which would include government ownership of farm fuel distribution facilities to ensure continuous supply.
Ontario Chamber of Commerce	. Support is expressed for strong conservation efforts. . Getting farms off petroleum fuels is an important priority. . Agriculture must have priority classification in the event of energy allocation. . Risk capital should be available to farmers who want to establish energy-saving or producing projects.

Organization	Main Points
	. Specific recommendations for conservation in agriculture include: - improved insulation levels; - installation of heat exchangers particularly in tobacco curing sheds; - matching heating and ventilation equipment to heating load to prevent overheating, overventilation and heat loss; - installing large diameter fans for summer ventilation and increasing use of natural ventilation; - use of double glazing for greenhouses and insulation on concrete walls; - use of heat recovery equipment for milk coolers; - reclaiming heat from exhaust air of livestock buildings and; - reclaiming exhaust air from crop dryers for recirculation to the drying section;
	. With respect to fuel substitution; OCA noted - solar applications such as pre-heating of ventilated air from livestock buildings and use of passive solar collectors for farm buildings are cost-effective; - ethanol blends are suitable for use in agricultural equipment; - burning of crop residues for grain drying shows promise.

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